A Systemic Model for a Building Performance and Condition Evaluation for Primary Schools

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Abstract

The problematical situation at the centre of this research is the absence of consideration given to building performance issues in the asset management and building maintenance management of primary schools in the UK. The asset management methods currently used for the building maintenance and improvement of primary schools have remained unchanged for a great many years and this study focuses upon how well the conventional methods of asset management serve the building occupiers. It considers how asset management could be impacted upon by applying techniques that have emerged in recent years from Post Occupancy Evaluation (POE) and Building Performance Evaluation (BPE).

Research carried out on the impact of classroom internal environments strongly suggests that good environmental conditions significantly improve the attention levels of the children being taught in them often resulting in improved activity and productivity levels. The literature review also suggests that building owners and occupiers are making higher demands from their buildings to meet their requirements for better internal environments and improved environmental performance.

From a study of a large, UK Local Authority a conceptual model was developed using Soft Systems Methodology (SSM) taking account of a number of perspectives and suggesting a possible process for considering condition and performance issues together. This process follows the format of the POE in assessing energy performance, environmental performance and occupier feedback but is supplemented by a building condition appraisal. The combined process was then assessed using an integrative framework applying the assessment criteria of SSM to compare the proposal with the conventional approach.

The findings of this study suggest that the Head Teachers of primary schools were very interested in looking at building performance alongside other asset management objectives. In many cases when Head Teachers were made aware of the consequences of achieving good environmental performance they wanted to check the air quality in the teaching areas. They were also interested in using other techniques to identify and act upon any deficiencies with energy and environmental performance and with issues collected from an occupier questionnaire. There was a strong desire to ensure that building performance is assessed and those issues which are seen to be supporting the learning activity within the school given a suitable priority. It is therefore assumed that a building performance and condition evaluation (BPCE) could be adopted in some form to improve the present situation.

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Abbreviation	Meaning
BCS	Building Condition Survey
BPCE	Building Performance and Condition Evaluation
BPE	Building performance Evaluation
BRI	Building Related Illness
c	circa - about
CIBSE	Chartered Institute of Building Services Engineers
CO_2	Carbon dioxide
CSR	Corporate Social Responsibility
DfE	Department for Education
edn	edition
rev. edn	revised edition
2nd edn.	second edition
ed. (eds.)	editor (editors)
et al.	and others
FM	Facilities Management
HM Gov	Mer Majesty's Government
IAQ	Indoor Air Quality
IEQ	Indoor Environment Quality
IPCC	Intergovernmental Panel on Climate Change
n.d.	no date
no.	number
n. p.	no place
ONS	Office of National Statistics
pt.,pts	part(s)
para., paras	paragraph(s)
p., pp.	page(s)
ppm	parts per million
POE	Post Occupancy Evaluation
RIBA	Royal Institute of British Architects
RICS	Royal Institution of Chartered Surveyors
SBS	Sick Building Syndrome
SMIP	School Maintenance and Improvement Plan
suppl.	supplement
trans.	translator(s)
vol.	volume (as in Vol. 4)
vols.	volumes (as in Vols. 1-4)

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1.00 Introduction

1.01 Building performance and the need for improved, sustainable practice

The earliest incentive for constructing enclosures to human activities has been shown to be the need to create a comfortable microclimate to act as a retreat from the inhospitable climate. All major civilisations to date have relied upon the construction of buildings to fulfil their environmental needs both physical and psychological (Banham,1969, p19). Throughout history examples can be found that demonstrate how great care and ingenuity has been applied to achieve desirable internal environments in some of the worlds most inhospitable climates (Preiser, Mallory Hill, Watson, 2012). It was the founding motivation for building, to convert inhospitability to comfort, utility or spiritual accentuation.

A measure of the effort and desire to provide built solutions to the problems confronting early builders was the incredible permanence and longevity of what they built. In some cases the amazing ingenuity that they built with exhibited outstanding technological development for their time such as Stonehenge in Wiltshire, 2800BC or the housing at Skara Brae in the Orkney Islands of Scotland, 2000BC (Balcombe, 1985). Buildings such as these show how the desire to construct to satisfy aspirations led to achievement and technological advancement.

The development of the technology used in building and the performance of structure and envelope has influenced design and aesthetics and innovative thinking has produced a range of techniques and methods for the environmental management of buildings. As human beings have progressed their ambitions for environmental comfort has broadened and greater understanding and the use of more sophisticated techniques has developed. A desire which today can be seen in our conviction to build sustainably in order to protect our environment now and in the future.

We are confronted with the need to change direction, to divert from the influence of fossil fuels and to find more sustainable solutions to our building requirements. It is a time for reflection upon what we have been striving to achieve and to reconsider the options and resources available to us and to rethink the way in which we use them. In considering the existing built

environment and the management of its transition to a more sustainable future it is necessary to question the process of conserving and maintaining the built environment and what we want from it.

It is difficult to understand why it took such a long time for us to accept that it was human behaviour that was polluting our environment to such an extent that it would be irreversibly damaging. Repeatedly generations seemed to believe that the mistreatment of the natural environment and the plunder of its resources would somehow be healed by nature regardless of the scale or severity (Carson, 1962). From the advent of the industrial Revolution and the birth of mass production the polluting of the environment reached new heights and continued on an increasing trajectory until the later part of the twentieth century before it was considered necessary to look for more sustainable practices to ease this burden. The development of a sustainable thinking culture has been seen to be a painfully difficult process as it opposes the primitive human instinct of putting ourselves before all else; an instinct that has served our species so well in the struggle for survival that we are naturally reluctant to change (Sassi, 2006, p4).

A key moment in the process of acceptance of responsibility for climate change was the founding of the Intergovernmental Panel on Climate Change (IPCC) in 1988; it initiated the provision of robust scientific evidence, offered a continuous review and much closer monitoring of the changing climate (Roaf, 2004, p1). The continued recognition of the anthropogenic problem and its association with climate change has led to an enhanced level of attention into what needs to be done to control the problem. It has led to the current agenda for a move towards a society that is less dependent upon fossil fuel, more sustainable and energy efficient. As a result there is now a much greater understanding of the performance of our built environment and the ability to measure and judge the impact of building design and controlled internal environments (Graham, 2003, p7).

For any building to be described as ‘Green’ or ‘sustainable’ it has long been established that it is essential that the environmental impact of all of its constituent parts is evaluated (Harris and Borer, 1998, p3). This presents the obvious question as to what are the most significant aspects of this evaluation, as the process of detailed evaluation suggests extensive use of time and resources. The question of how should each and every environmental impact be measured and

should they be the same for all building types? The identification of the significant aspects of sustainable building for new buildings has been approached from a number of perspectives and there is an array of methods in use across the world for measuring the sustainability of new buildings. There are notably fewer prescribed methods for measuring the performance of existing building although some are beginning to be more widely used such as BREAM In-Use or the Green Star Existing buildings performance tool (BRE, 2016, Doggart, 2000). All of these methods utilise a similar format of measuring an aspect of performance and comparing it to some given benchmark which is usually the average for the building type or a regulatory level of performance for the period of construction; then some form of improvement against this for example to reduce water use or save energy through specifying a particular rainwater harvesting system or heating installation which results in some form of recognised merit. In most of the methods currently being deployed the criteria for making the judgement of performance is based on eight or nine areas, usually Energy and Emissions, Water Use, Air Quality, Materials, Waste Management, lighting, Ecology and Health and Wellbeing sometimes also including recognition for innovation or considering external influences such as Transport etc (Kibert, 2016).

The versions of these grading systems that are used on new buildings over their first or second years of occupancy have in almost all cases identified a ‘performance gap’. This is the difference between the calculated performance at the design stage and the actual performance in use. It often occurs as a result of the building process failing to deliver exactly what the design specified with material quality, installation and workmanship being identified as principal causes for the problem. However, occupier behaviour has also been identified as having a major impact on achieving the predicted performance (Bell, Wingfield, Miles-Shenton and Seavers, 2010). The need for an increased understanding of the reasons for the difference has led to an increased use, and development, of a detailed appraisal process known as Post Occupancy Evaluation. For many reasons Post Occupancy Evaluation (POE) failed to fulfil its potential and from the time of its first appearance in the 1950s for many reasons it failed to make an impact upon the problem. Today the POE has been shown to offer an opportunity to communicate a range of human factors to produce better performing buildings for all stakeholders (Watson, 2012, p85).

The increased focus and investigation of ‘building performance’ and operating buildings in a sustainable way has been accompanied by a desire to achieve better economical use of existing

buildings. The possibility of improving energy consumption without diminishing occupier comfort has led to efforts to examine in detail all operating costs and to reduce the environmental impact of buildings. It is these issues that have become key for our global built environment (Wilkinson, 2008, p4). Sustainable building design and sustainable development has been defined in a great many ways but one which has remained widely quoted was contained in a report produced for the World Commission on Environment and Development in 1987 and states that: ‘sustainable development should meet the needs of the present without compromising the ability of future generations to meet their own needs’ (Brundtland et al. 1987). The Brundtland Report appears to have been accepted as a morally and ethically acceptable objective for most western societies and has been borne out by the positive public opinion and reaction to governments and organisations that have adopted CSR (Corporate Social Responsibility) within their operations (Fenn, 2013). However whilst the Brundtland Report was an internationally accepted document that called for sustainable development and social justice, an unparalleled accomplishment at the time, it was also accused of accepting that negative impacts and trade-offs were necessary so as not to hinder economic growth and development (Birkeland, 2008).

The dominant focus for improving sustainability and quality has been on the provision of new building and this is a logical approach as it is an obvious place to start by building in a way that is sustainable first before looking at how to correct what has already been built. However the existing building stock is vast and underperforming to a very high degree (Styring, Jansen, De Coninck, Reith, & Armstrong, 2011). In the UK, it has been estimated that over 70% of the existing building stock will remain in use up to and beyond 2050 (Styring et al. 2011). In many other countries in Europe there is a culture for preserving the built environment for its historical significance and over forty percent of the entire building stock are pre 1960 (Economidou et al. 2011).

The excessive use of energy to heat the ageing building stock and their lack of sustainable credentials can be seen as only part of the problem. The continual deterioration of the fabric of many of these buildings and the lack of quality internal environments within them require complex solutions and decisions that may radically affect external appearance of such buildings or seriously challenge the need to preserve them. The recently created Global Alliance for Buildings and Construction at the COP21 conference asserted that ‘layering of technologies onto

a building only gets us part of the way to high performance buildings that have low environmental impact' (Keeler and Vaidya, 2016).

Considerable effort and investment has been made in the UK and Europe to ensure that all new development achieves much higher performance standards in pursuit of the goals set by the Intergovernmental Panel on Climate Change (IPCC) and their agreed targets to reduce greenhouse gas emissions (Roaf, 2004, p38). The UK government set a legally binding target in the Climate Change Act 2008 to reduce net CO_2 emissions in 2050 by more than 80% from the 1990 baseline and more recently to reduce emissions by 57% by 2030 (The Carbon Accounting Regulations 2015). The CO_2 emissions from non-domestic buildings account for approximately 18% of national total emissions and as such an imperative exists to reduce the emissions from these buildings, including schools, to achieve the 2050 target (Carbon Trust, 2013).

It is often the case that those who manage buildings such as Asset Managers and Maintenance Managers place different emphases on the environmental needs of the occupants and the maintenance of the building structure, fabric and services. In places where the prevailing climate is severe it is often found that the internal environment and air quality is considered to be a high priority together with the quality of the fabric maintenance (Full and Tabassi, 2014). Long term practices and habits lead to the unquestioning repair and maintenance of buildings with a view to restore them to their original form, regardless of what internal environment they may be delivering, what energy they may be using or what satisfaction they offer to their occupiers.

There has recently been an increasing emphasis upon the relationship between workplace performance and facilities management and this is becoming more important as facilities managers are having more demands placed upon them from building occupiers and owners (Tarcan et al., 2004). It has been shown that workplace conditions are an important factor for the health and performance of the occupiers and businesses have been shown to be more profitable when their staff are provided with better workplace environments (Marshall et al, 2002; Fisk, 2000). Physical stress factors amongst office workers have been found to be induced by such things as poor indoor air quality, noise, vibration, inadequate lighting, excessive standing, poor seating, awkward movements, repetitive motion and other ergonomic problems (Walker, 1993; Dalbokova and Krzyzanowski, 2002). Recent research has demonstrated that CO_2 is a direct causative agent in reducing performance and that CO_2 levels above 0.25% (2500ppm) can have a

significant impact on a person's ability to concentrate and to perform even basic tasks. In a series of tests carried out using a controlled environment chamber, participants underwent a series of specially developed task and initiative based computer tests. Ventilation within the chamber remained constant and CO_2 levels were varied by injecting pure CO_2 into the chamber and maintaining constant CO_2 levels throughout the duration of the tests. The results demonstrated that a CO_2 concentration of 2500ppm significantly reduced the participants' performance ability in seven out of the nine tasks (Satish, U. et al., 2012). People do not perform well in environments that leave them feeling uncomfortable and this is true for all building user activities, that is to say, the same for the primary school classroom as it is for the office. However, environmental impacts upon children have been demonstrated to be even more marked because of their higher breathing and metabolic rates (Annesi-Maesano et al, 2012).

In the most extreme cases building occupants have been found to suffer from such symptoms as irritation to their eyes, nose and throat, dry skin or dry mucosa, fatigue, headaches, nausea etc and are subsequently ill as a direct result of their occupation. Buildings that cause these symptoms have been referred to as being affected by Sick Building Syndrome (SBS) (Thorn,2000). The term 'Sick Building Syndrome' was first used by the World Health Organisation in 1986, when they also estimated that 10-30% of newly built office buildings in Western Europe were suffering from indoor air problems. Several factors have been found to be associated with SBS including; mechanical ventilation, air-conditioning, evaporative humidification, volatile organic compounds, illumination, particulate matter, noise, indoor temperature and psychological factors (Adan & Samson, 2011). In the 1980s few people were interested in measuring building performance, even of new buildings, or understanding the effects that such buildings could have on the lives of their occupants. Twenty to thirty years earlier POE techniques were available and being put to good use to identify such issues and it was found in many cases that the remedial works to correct them were sometimes carried out with no-cost or low cost solutions.

Whatever factors are the source of SBS, without detection, they are very likely to lead to a degree of discomfort for the occupiers and a subsequent loss of productivity or absence from work. If a building has only one minor problem and this leads to only a single symptom being identified then if it is undetected and left unchecked it presents a risk to all of the occupants that

are exposed to it. In primary schools the risk to children is enhanced (Annesi-Maesano et al, 2012) and so it is in the interests of providing good learning conditions and the general well being of the children that measurements are made which would identify the existence of any problem and enable a solution to be sought. School building has followed similar construction trends as mainstream building and this makes it likely that as many of the problems that lead to SBS and that are induced by building design will be present in school buildings. Designs that have failed to provide good air quality or adequate lighting, heating, or relative humidity etc can only be detected by a systematic measurement process and as these issues are identified cost effective solutions can then be found. Primary school buildings are likely to be prone to some of the factors that induce SBS such as building dampness, temperature, illumination and should be identified and eradicated (Sahlberg, Smedje & Norback, 2002).

Building related illness (BRI) is quite different from SBS as it comprises specific diagnosable symptoms caused by certain etiological agents for example chemicals, bacteria, fungi, mould etc. Most complainants of the symptoms of SBS report relief soon after they leave the building whereas complaints relating to BRI usually require prolonged recovery times after leaving the building (Gouldstein, 2010). An example of this is Legionnaire's disease which is associated with the bacteria Legionella pneumophila which could be present in high concentrations in certain conditions within a building. SBS does not have any known cure; alleviation consists of removing the affected person from the building associated with non-specific symptoms. BRI, on the other hand, utilises treatment appropriate for the contaminant identified within the building (e.g., antibiotics for Legionnaire's disease). In most cases, simply improving the indoor air quality of a particular building will attenuate, or even eliminate, the acute symptoms of SBS, while removal of the particular source contaminant would prove more effective for a specific illness, as in the case of BRI.

1.02 Primary Schools as a subject for the BPCE

Primary schools in the UK use over 800 million kWh of energy and emit approx 1.6 million Tonnes of CO_2 per year which amounts to 5% of UK non-domestic emissions (CIBSE, 2012, House of Commons International Development Committee, 2016).

In 2012 the birth rate in England and Wales rose to a peak of almost 730,000 and has since levelled out to just under 700,000 between 2012 to 2016 (Office of National Statistics, 2017). This represents a steady rise from 600,000 in 2002 and as a consequence it has been estimated that 282,000 more primary school places will be required by 2019 (DfE, 2017). The nursery & primary school population has been rising since 2009 and reached 4.58 million in 2017. However, the rate of increase is slowing, due to the now falling birth rates, and the population is projected to stabilise in 2019 at 4.66 million, as predicted in the 2015 report. The Department for Education announced, on 9 February 2015, indicative allocations for school condition funding for the 3-year period covering financial years 2015–18 (DfE, 2017). These allocations were based on a new approach to investing in the condition of the education estate and made in respect of Direct funding for individual institutions through Devolved Formula Capital and funding for those bodies responsible for individual institutions through the School Condition Allocations. This represents a reformed approach to the allocations so that funding for responsible bodies is now based on the condition of their buildings, as well as on their pupil numbers and school characteristics. This approach recognises the need to repair existing defects as well as provide ongoing maintenance to keep all buildings in good condition over their lifecycle. There are approximately 24,347 primary schools across the UK (DfE, 2016) and these schools are housed within a very wide range of building types and ages. The number of and type of schools change constantly with a great many new free schools emerging and in almost all cases being housed in existing buildings frequently converted from other uses to school buildings. The rate at which new primary schools have been built in the UK has been 10-15 per year and so the vast majority of primary schools are housed in older buildings and there is therefore a clear and urgent need to look to find sustainable means of maintaining and improving older building stock whilst also finding new ways of obtaining greater performance from them. The size of this sector of the UK Construction Industry is now a very significant £1.2 billion (DfE, 2017). The need to identify a process to maintain and improve primary school buildings to high standards in terms of sustainability and performance is therefore great and urgent for all stakeholders.

The CO_2 emissions, the amount of public money that is spent and the amount of energy consumed together with the variability of building maintenance and performance across the 24,347 primary schools in the UK provides a very good justification for looking more closely at the performance of primary schools and how they use the considerable amount of energy that

they consume. However it also presents an opportunity to look at a suitable method for examining their building performance and their asset management processes in supporting good performance. This objective points to the use of the framework of POE techniques developed in recent years to assess building performance which is also closely linked to the needs for more sustainable building management techniques through the more informed use of energy. The starting point for this work is to measure what currently exists in terms of condition and enclosed environment and to look at the priorities and solutions with an emphasis upon sustainability and achieving optimum teaching conditions. It should also assist head teachers to realise the importance of adopting environmentally sensitive thinking in all of their actions and seek to deliver the best possible performance of their buildings.

Primary school buildings provide an excellent opportunity to examine and contrast the relationship between building performance and the achievement of good building maintenance standards as the buildings have similar use patterns and all require a level of building performance to achieve the user objective of providing the best environment for educating children aged from five to eleven years. They have a very similar format of classrooms and educational support areas, an assembly hall, staff rooms facilities, administration facilities, etc., and the teaching areas are used with very similar types of application and teaching practices often dictated by head teachers who have consistent and well aligned thinking as to how best to achieve their objectives. This provides an excellent consistency in their use and enabling similar applications to be carried out and compared.

The day to day practice of maintaining school buildings involves a constant process of evaluating priorities and identifying packages of work which are then aligned to available budgets. The data used for the purpose of planning building maintenance activity is acquired in a number of ways but mainly through a building condition survey supplemented by cursory observations by the Head Teachers and their advisors. The Head Teacher's final decision will be influenced by the information provided regarding the need to deal with one particular issue or another. It is therefore important that the advice provided to Head Teachers contains as much useful information as possible about what might affect the performance of the school building and how this will impact upon the learning process. This consistency of process across a very large number of primary schools provides a further incentive for making them the subject of a

building performance and condition evaluation as by having the same processes for decision making the process itself can be examined. This cannot be seen to be the case for many other building types that could be considered for being the subject of this research such as retail units, office buildings or factories as these are much more likely to have diverse user requirements and more rapidly changing use patterns.

In the UK our climate generally requires buildings to be heated in the winter months from late September to early May and the use of natural ventilation, i.e., opening windows to maintain reasonable levels of comfort in the summer months. This simple, relatively low cost solution has frequently been the adopted environmental practice for Primary Schools with the exception of summer cooling being required in some extreme cases. As it is the intention of this study to examine the relationship between the internal environmental conditions together with other aspects of building performance this presents the primary school as an ideal subject upon which to research the building condition and performance relationship under a very consistent set of circumstances.

One of the most significant reasons for choosing to carry out this research on primary school buildings was the availability of information and the willingness of the management and teaching staff to contribute to the research activity. Information gathering on such things as monthly consumption of gas, electricity and water can be difficult and time consuming and often requires the researcher to make some assumptions which become confounding issues. In the district where the schools used for this study are based the local authority collected monthly data for their schools and this was readily available making this task much simpler and less time consuming. Perhaps the most significant reason for this selection of primary schools as the subject of the research is that the full time employment of the author is based upon the maintenance and improvement of primary school buildings and hence the subject matter of the research was embedded in the author's work.

There are continual demands being placed upon improving the quality and sustainability of our built environment and it is particularly so with the provision of new school buildings and the refurbishment of exiting school buildings (Birkeland, 2008). It is extremely desirable that our children are educated in buildings which are capable of providing the best possible environment

for Health, Wellbeing and learning. Building performance has justifiably more focus on the production of new buildings than the maintenance of the existing sometimes ageing estate. However it has been demonstrated that building performance and condition assessment cannot be separated as the condition of a building is often a contributing factor to the building performance (Abbott et al, 2007). The deterioration the fabric of a building has been shown to be a major factor in the depletion of building performance. This is obviously seen in the failure of damp-proof courses, roofing failures or the decay of timber windows and components etc. Whilst this subject of the connectivity between building condition and performance is at the very heart of this research it also emphasises how important a task it is to ensure that older buildings are well maintained.

1.03 Problem Statement

The rationale for this research has been born out of a desire to improve the connection between building maintenance, building performance and occupier satisfaction and to consider the possibilities of prioritising building improvements using a totally evaluative method. There are two questions that should be asked of primary schools, firstly; are they efficiently achieving good learning conditions with the energy that they use and secondly, are they expending their budgets for their buildings in the right priority, ie not just building condition but building performance.

The first question is answered by conducting an energy audit and assessing what forms of fuel are being used and how much in what weather conditions. This followed by an environmental appraisal to see what is being achieved and thirdly to seek occupier opinion to support the findings or contest them. In doing this initial work we effectively conducting a POE. In answering the second question the findings from the POE would need to be merged with the findings from a building condition survey to produce the whole picture and producing a list or programme of works required. These two activities seem to be capable of becoming one by simply replacing the walkthrough inspection of the POE with the full condition survey and this study focuses upon how this could be done and what it could achieve.

Having established the importance of sustainable building practices in primary schools it is equally important to establish how this can impact upon the management of these built assets. Currently there are a number of differing surveys and evaluation processes available which offer bespoke services like the BPE. They offer the building owner and user an insight into how their building is performing and what might be done to improve things. This question is part of the rationale for this research as the current methods give little consideration to sustainable behaviour, environmental sensitivity or, most importantly, the consequences of building maintenance on building performance.

It is the latter which seems to suggest an obvious approach of introducing the concept of sustainable and environmentally friendly practices into the field of asset management. By raising the standard of performance — or at least recognising the lack of good performance — the overall combined effect can be considered and prioritised and acted upon where budgets are available. The concept of managing buildings through an understanding and controlling of the workplace environment is not a new concept as it could be said that within the field of Facilities Management the emphasis has been more towards building performance and occupier satisfaction.

The current methods deployed in the field of building maintenance management including the gathering of data on building condition and the production of planned maintenance schedules detailing the extent to which works are to be completed over time have remained unchanged for many years (RICS, 2009). The standard of maintenance work has long been recognised as having an important impact on the quality of the built environment and as Seeley observed in 1976; ‘there seems little doubt that society will continue to expect higher standards of maintenance in both new and existing properties’ (Seeley, 1976, p5). The principal criteria which influence the decision to carry out maintenance work have been generally accepted as: cost, age and condition of the property, availability of adequate resources, urgency, future use and ‘possible sociological considerations’ (Chudley, 1981).

This last category recognises that there is an impact made by buildings, and specifically their appearance and condition, on the people who occupy them or who simply walk past them to work every day. The provision of effective maintenance to keep buildings to a given standard and the efficient use of scarce resources is beginning to be approached in a much more informed way. The relationship between the condition of the building fabric and its overall performance

both in terms of the energy performance and the quality of the internal environment are being examined more critically now than ever before (Chanter and Swallow, 2007 p19).

There are indications that the level of performance of buildings is also becoming a more important factor in determining the standard of maintenance and in some cases leading to decisions to improve particular elements rather than just effect repairs (Fontana, 2012, p155). Understanding and balancing the priorities of achieving good maintenance standards whilst also attaining good building performance is a difficult task. It is however a task that must be addressed if we are to maximise the benefit of our new and existing buildings. The existing asset management practice addresses this problem situation by examining structure and fabric separately from building services and without assessing any impact that work of this nature may have on building performance and this is the research problem that this work seeks to address.

This situation may have come about as a result of only perceiving building performance standards as something that needs to be tailored to specialist building user needs and in many cases not being considered until a problem arrises. Most predominantly the importance of building performance issues are assumed to be so minimal that the deployment of cost and resource to assessing them cannot be justified or they are simply not recognised at all. One of the most significant barriers for achieving the goal of improving energy efficiency of buildings has been identified as being the lack of knowledge about the factors determining the real energy use of buildings (Fabi, Anderson, Corgnati and Olsen, 2011, p 2822).

The problem situation that exists can therefore be seen as the lack of building performance consideration in the process of maintaining and using occupied buildings and this has been identified as a potentially misplaced priority in the overall process for many building types. It is difficult to identify reasons as to why the POE approach has not impacted upon conventional building maintenance approach. There have been a great many publications on the need for more sustainable buildings and on the application of a range of low carbon techniques for achieving good environments within buildings some identifying problematic issues with the technology (Palmer, Terry & Armitage, 2016). However few have focused entirely upon the need to refine building maintenance strategy with our enhanced knowledge of building performance. Even though good building maintenance is essential for the adequate performance of buildings, and POE generally offers a form of evaluation which highlights the occupants' needs, there is yet no

formal approach to the incorporation of POE data as a tool for maintenance planning or asset management (Pereria, Rodrigues & Rocha, 2016).

One reason for this is that in the UK there appears to be an acceptance that POE and Building Maintenance are distinctly separate fields without a valuable connection. Owners and occupiers are often presented with POE formats which contain a great number of techniques and applications which, whilst offering a useful purpose and are very much part of the performance makeup of the building, they have time, resources and cost implications which deter them from being carried out. There is however, a developing realisation that building performance and building condition can not be separated and that condition is a contributing factor to performance (Abbott et al, 2007)

An important factor in the lack of interest in examining building performance and asset management is the lack of skilled personnel available to carry out the evaluations and there are few professionals who have a sufficiently detailed knowledge of building performance as they have no specific training in the techniques of evaluation (Bordass and Leaman, 2005). In spite of considerable reflection and writing by academics and researchers, there is no particular empirical technique or tool associated with the practical use of POE (Vischer, 2001).

Other factors which have effected the use of POE techniques have been seen to be cost and time which are both evident in the number of tasks of both gathering data and carrying out specific measurements. The time in gathering data is unpredictable as different organisations deal with energy data in different ways and establishing accurate monthly usage may involve a detailed investigation. The achievement of good data from the physical measurements of building performance may also be an unpredictable process often involving the use of expensive equipment.

There has been a concerted effort made by practices, institutes and researchers to remove barriers to POE and challenge the misconceptions. The RIBA has re-introduced POE into the Plan of Work under Stage 7: In use, and is producing a suite of guidance on POE and BPE to help practices integrate feedback into their work. The RIBA has also highlighted the way that the Research & Development tax credit system can be used by architects to reward investment in

research by allowing staff costs to be claimed back as relief on corporation tax. There is considerable work to be done in demonstrating these benefits to clients and there is a growing body of research into the social and environmental performance of buildings across health, education, housing and office buildings that rely on and have developed new POE methodologies (Hay, Bradbury, Dixon, Martindale, Samuel & Tait, 2016).

By questioning the practices developed within POE or BPE they might tell us things about the internal environment that we are not gathering and we can consider what would be the benefit in considering these factors alongside the conventional Building Condition Appraisals? These questions form the basis of the research and are centred upon the effectiveness of the current building maintenance practices. The research asks whether there should be a deeper questioning of the overall performance and how well the performance of the building meets the needs of the occupier.

1.04 Aim and Objectives

The overall aim of this research can be summarised as:-

To devise a systemic model for the assessment of Building Performance and Condition to improve current Building Management processes for Primary Schools in the UK.

In order to achieve this aim the following objectives have been identified:-

1. To review the development of Post Occupancy Evaluation and Building Performance Evaluation methods from their conception to the current usage.
2. To determine the existing asset management processes for primary schools and the current practices of collecting and using data.
3. To conduct an investigation of how Premises Managers, District Surveyors, Engineers, teaching staff and senior Managers perceive the performance of school buildings and the asset management process within a large UK Local Authority.
4. To Construct a conceptual model for the content and implementation of the Building Performance and Condition Evaluation using the preliminary investigation, a review of existing practices and the literature review.

5. To develop a building performance and condition evaluation process using the conceptual model and to analyse what benefits this offers and how the existing asset management process could be influenced by this approach.

6. To assess the benefit of adopting a derived set of practices from the perspective of a number of Head Teachers and to propose a Building Performance and Condition Evaluation specifically for Primary schools.

The improvement in the user experience and especially improvements to the teaching environment are a very important part of this research and creating a higher quality and more consistent environment within the classrooms is one of the ambitions of the BPCE. In order to improve something you must at first measure it and then seek to find the best and most economical way to provide a better product. Primary school maintenance programmes frequently include cyclical and planned preventative maintenance issues together with replacement of finishes such as carpets and redecoration work which offer the teachers something of an improved and freshened up classroom environment. However issues such as improving air quality or reacting to high humidity levels or obtaining the views of the teaching staff often fail to be addressed in a systematic way and it is also the aim of this research to seek to place these sorts of issues higher on the list of priorities of the head teacher and the asset manager.

Raising the importance of the building performance issues simultaneously emphasises the need to ensure that the condition survey data coincides with this renewed focus. This may result in less superficial data being captured on the condition of finishes or fittings or upon longer term maintenance predictions that may be contested by the Head Teacher at the time of their implementation. The streamlining of the building condition appraisal process by an agreed delegation to the site based staff could result in considerable time savings in carrying out the condition surveys. The physical measurement of the building performance such as the internal air quality, the lighting levels etc will also reduce the appraisal time of the condition surveyor and the information for the asset management process could be usefully condensed and enhanced.

2.00 Literature Review

In order to achieve the first objective of this thesis it was necessary to undertake a detailed review of the literature encompassing the origins and the development of POE and BPE for all types of building and latterly to focus the achievements of this development upon an application relevant to primary school buildings. The history and gradual evolution of the content of the POE and the BPE over the past 50 years is an essential part of this research and it identifies the most significant fields or elements in which the assessments take place and the many and diverse techniques attributed to those fields. Consideration is also given to what other forms of building performance assessment have emerged over the past fifty years and what impact they have had on the content and procedures being followed today.

Each field of the POE/BPE is examined and its worth considered together with the range of techniques within each field. An assessment is made of the merits for their inclusion within a BPCE for primary school buildings with regard to theory and practice. The extent to which any of these techniques are being adopted within the conventional asset management process will also be considered and the historical development of the school building condition survey process critically examined. This investigation is directed towards understanding what, if anything, the techniques that have emerged have added or could add to the conventional process from the perspective of both building users and those engaged in the asset management process.

2.01 The development of POE and the use of BPE for existing buildings

A Post Occupancy Evaluation attempts to assess the behavioural response of a building's occupants to the building as they experience it in the early period of its use. It is also a detailed measure of the energy performance of the building and it ensures that the building is delivering its predicted sustainable performance whilst also being an efficient enclosure of a comfortable microclimate with a design that is suitable for the pursuits of the occupiers. A deeper significance is applied to POEs, however, as over time they become an instrument of quality control. This means that in much the same fashion as quality control in manufacturing influences the design and construction of products, so the POE becomes the measure of quality in building design (Betchel, 1988).

In the 1960s, evaluation case studies of university dormitories were carried out by Sim van der Rijn of the University of California, Berkeley, and Victor Hsia of the University of Utah. While

not called post-occupancy evaluations (POEs), these evaluations were among the first systematic attempts at assessing building performance from the building users' point of view (Preiser & Nasar, 2008). The phrase 'Post occupancy Evaluation' was probably first used in the early 1970s in the USA to describe the process of assessing buildings in use, initially from the occupants point of view. There is some debate about who first used the phrase, Wolfgang Preiser and Gerald Davis both claim not to have done so despite a great many believing that one of them did (Leaman, 2004, p 492).

The focus of the early POEs was more upon systematic benchmarking of types of building to enable comparative performance. Zimmerman and Martin (2001) view POE as *The logical concluding stage of the design process, with the feedback loop providing a valuable platform for lessons to be learnt from occupiers. This identifies both how the existing space could be used more effectively, and provides information that could feed future design of similar buildings.*

The ability of the process to identify variations in the quality of different environments, identifying emerging problems or discovering acceptable adequacy and learning from feedback from experience are the main themes in Leaman's definition:

'Post Occupancy evaluation has been defined as' trying to answer two broad questions, how is the building working? And is this what was intended? It is about real world outcomes and their consequences (ends) rather than design prescriptions (means). It aids learning from experience to improve the next generation of buildings, a kind of quality control writ large' (Leaman, 2004, p491).

This definition is specifically focused upon the designers' intentions and the actual measured performance of the building whereas other writers have looked to define POE as the means of identifying occupier satisfaction and fitness for purpose. Turpin-Brooks and Viccars (2006) considered that the rationale behind POE is to consider the extent to which a building or facility satisfies the needs of its end users and to identify ways in which design, performance and fitness for purpose can be improved.

In a very detailed guidance document produced by Blyth, Gilby and Barlex (2006) the definition took on the all-embracing view of the building from the inception of the building to the end of its life cycle.

The term POE is used as an umbrella term that includes a review of the process of delivering the project as well as a review of the technical and functional performance of the building during occupation. POE is a way of providing feedback throughout a building's lifecycle from initial concept through to occupation. The information from feedback can be used for informing future projects, whether it is on the process of delivery or technical performance of the building, (Blyth et al, 2006).

POE has clearly been an evolving subject over the past fifty years and although latterly it is a highly regarded effective process for evaluating the as-built achievement for new buildings the extent of its usage is disappointing. The current perception of the purpose of POE suggest that '*it should cover user satisfaction, technical performance, financial performance and the impact of the built environment on the business or process and to ensure sustainability objectives are met we need to more regularly evaluate buildings in use by an effective process of Building Performance Evaluation (BPE)'* (Coats, Arayici & Oztyrk, 2013).

The term Building Performance Evaluation can be traced back to the early work of Manning (1965), who was particularly concerned with work environments and offices. The long-term aim of his research was the academic development of an understanding of this "total environment". His multi-disciplinary studies and publication was accomplished by individual reports from the four research staff members this included a general survey by the architect of literature relating to office design and environment, an account by a geographer of the general characteristics, population and location of post-war office buildings in England and Wales, a report by a physicist of the results of surveys in offices of noise, lighting, and thermal conditions in winter and summer and a report by a psychologist of the response of the staff of the Co-operative Insurance Society in Manchester to their working office environment.

This approach was further examined in 1966 when a group of 20 architectural and engineering practices together with The Ministry of Public Building and Works and the publishers of the Architects Journal agreed to sponsor the setting up of the Building Performance Research Unit within The School of Architecture at the University of Strathclyde. Dr T. Markus, professor of Building Science was appointed the director of a team that mirrored Manning's team and they built their work around the three basic themes of design, people and resources basing their studies upon 50 comprehensive schools in Scotland. The research claimed that the choice of the

schools was simply a convenient field for the study and the Unit claimed no specialist knowledge of school design.

The findings of this Unit were largely formulated to serve the interests of their sponsors who were mostly architects and Markus describes their interest as being *'in the form of demand for results which would be practical, simple and of immediate use to them'* (Markus et al, 1972, p171). The Unit commenced its programme of research in 1967 and ended in 1971 and the team of 7 produced over 130 publications during this time. Their work predominantly focused upon design, cost, spatial issues and the use of computer science in assessing building performance and achieving occupant objectives. They did consider appraisal methods for natural daylighting in classrooms and experimented upon the effect of acoustic performance in the schools.

The RIBA recognised that a lack of 'scientific exploration' existed into the successes and failures of construction projects. This led to the inclusion of the final stage of the RIBA's 'Plan of work', Part M: feedback. This evaluation stage was seen as the 'most cost effective way of improving service to future clients (RIBA, 1965). However, despite this development, interest in building performance within the RIBA plan of work was soon lost due to the associated fees, enhanced insurance, liability, and its failure to be seen as an Architect's responsibility, (Cooper, 2001). As a result, RIBA removed the Part M Stage of their plan of work, as it was reported that clients were not prepared to pay additional costs for the process, coupled with the fact that RIBA did not want to give the impression that this stage was compulsory, (Preiser and Vischer, 2005). However, the RIBA has now re-introduced POE into the Plan of Work under Stage 7: In use, and is producing guidance notes on POE to help practices integrate feedback into their work (ribaplanofwork.com).

Hartkoft, Loftness & Mill (1986) introduced the concept of Total Building Performance (TBP) which was a process that measured the 'fundamental building performance mandates' of thermal comfort, acoustic comfort, air quality, lighting comfort, spatial comfort and building integrity. It also endeavoured to define the physiological, psychological, sociological and economic limits of acceptability of these mandates and to clarify their relationships with each other. Whilst this enormous task was laudable for its coverage of a considerable breadth of building performance issues, however it would also prove unmanageable and expensive to complete in its entirety. Douglas (1996), in a paper appraising the TBP process and diagnostics criticises the process for its lack of 'dynamism' and questions the validity of the process in the light of developments of

POE in the US and the Building Quality Assessment (BQA) process developed by the Centre for Building Performance at the Victoria University of Wellington, New Zealand. Coper fails to explain exactly what he meant by lack of dynamism but the scale and cumbersome, subjective nature of the assessment is what made the process impractical.

Wong & Jan (2002) apply the Total Building Performance (TBP) concept (see figure 1) to a secondary school in Singapore and conclude that '*The usage of a walk through, simple instrumentation, and an occupancy and use analysis to investigate the school environment has been sufficient to give preliminary and simplified findings'.* It is however, difficult to understand the interrelationship between the building performance mandates. Another view of TBP expressed in this paper is that *TBP is in essence, a framework comprising a comprehensive set of objective and subjective field evaluations in all performance areas simultaneously so as to achieve a healthy environment to facilitate the function of the occupants in the space.*

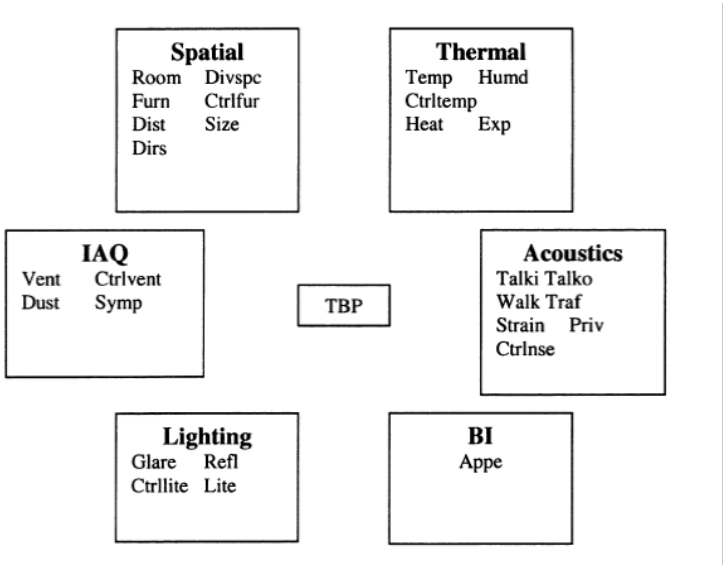


Figure 1, Total Building Performance as a function of its parameters, Space, Thermal performance, Internal Air Quality, Acoustic performance, Lighting and Building Integrity (BI).

The issues under consideration within the Spatial elements are as follows; a measure of the space to move around (Room), the division of personal space (Divspc), the arrangement of

furniture (Furn) the control over the furniture arrangement (Ctrlfur), the distance of seating from the blackboard (Dist), the size of tables and chairs (Size), and a range of other classroom dimensions (Dirs). The Thermal Element of the assessment contains a measure of temperature (Temp) and humidity (Humd) and a measure of the ability to control the temperature (Ctrltemp), there is also a measure of overheating (Heat) and the advent of health problems associated with thermal issues (Exp). Within the IAQ element the issues identified are; the level of ventilation in classroom (Vent), control over ventilation levels (Ctrlvent), the presence of dust (Dust), and health problems experienced from bad IAQ (Symp). The assessment of acoustic performance is particularly extensive containing seven measurables including the effect of people talking inside the classroom (Talki) and outside (Talko), the effect of people walking past the classroom (Walk) and traffic noise (Traf). It also attempts to assess the effect of noise levels on holding private conversations (Priv) and people needing to strain their hearing to listen (Strain), finally it assesses the means of controlling noise levels (Ctrlnse).

Lighting is assessed upon four measurables namely; the presence of glare (Glare), problems associated with reflection (Refl), the adequacy of artificial lighting (Lite) and the ability to exercise control over lighting levels, (Ctrllite). The final field of evaluation is that of 'Building Integrity and this contains only one measure which is the effect of appearance of class on its occupants (Appe), (Wong & Jan, 2002).

Although the aim of Hartkopf et al. was to provide a comprehensive list of building performance mandates which they could claim to have achieved they could not make the same claim to reducing subjective appraisal. Each of the 'building performance mandates' has according to Hartkoft, a 'comfort zone' establishing the limits of acceptability for each different type of occupancy. The trasdiciplinary approach to collecting measurements and assessments is confirmed as an effective diagnosis.

In the mid-90s, Preiser & Schramm (1997) undertook a collaborative piece of research on the topic of cross-cultural POEs, issues pertaining to the building delivery cycle, as well as the life cycle of a building, what could be described as a Meta level approach to building evaluation. This exercise resulted in an integrative framework for building performance evaluation being developed. In this framework, post-occupancy evaluation represents only one of six internal review loops, and the framework focuses on the entire life of a building, as well as the notion of feed-forward into the next building cycle (see Figure 2).

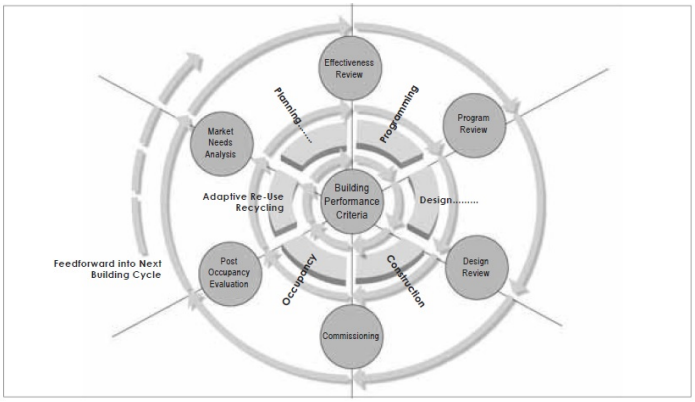


Figure 2, Building Performance Evaluation Process Model (Preiser & Schramm 1997)

The model illustrates a gradually evolving knowledge base that draws upon all aspects of the life cycle of the building with building performance criteria at the heart. Preiser's model of what he defined as 'Building Performance Evaluation' was clearly not about to be implemented as a workable process without further refinement and economic justification. Whilst the model has a balanced elegance to it, it lacks practicality and the issue of occupancy seems misplaced suggesting that the POE is an event at the end of the occupancy period and not an on-going or early stage assessment of occupancy in use.

The Probe surveys (Bordass, Leman and Russyfeldt, 2001) were carried out over a seven year period from 1995 to 2002 and were underpinned by three established elements, occupant feedback, energy analysis and airtightness testing. They did not include, for example, Environmental assessment, space utilisation, costs-in-use, or aesthetics; all of which might at the time have seen to be part of a fully rounded POE or BPE. Bordass explains the absence of these parameters as being due to the fact that their inclusion would have made the project unmanageable within the available resources; and because there were no tried and tested methods and benchmarks that could be relied upon (Bordass, Leman & Russeyfeldt, 2001). This could be seen to be a clear exclusion of the work being carried out by Hartkoft et al. the 1990s justified on the grounds of practicality and prioritisation of importance.

The Probe surveys carried out by W. Bordass Associates was 50% funded by the Department for the Environment, Transport and the Regions (DETR) and it involved a detailed performance

assessment of twenty prominent new buildings many of which had achieved considerable success with the BREEAM rating system. It was generally agreed that the Probe surveys '*helped to increase the awareness of the building industry and its clients to factors for success in building performance, and to where things can go wrong'*. It proved to be timely, as the UK building industry was being asked to respond to pressures for improvement to product quality and delivery, sustainability and business performance (Bordass et al, 2002). Following the publication of the PROBE results in Building Services Journal a considerable number of the professional advisors involved with the original construction of the buildings strongly contested the Bordass findings with a very public heated debate and legal actions. The episode offers a demonstration as to why POE has been unpopular.

Way & Bordass (2005) developed the Soft landings framework for the handover and monitoring of buildings in use and this process offers a solution to what Bordass considered to be the most significant problem with building performance i.e. the interpretation of the occupiers as to what is required to optimise building performance. This supports the position that it is necessary to assess the building performance as the building comes into use to close the loop between design expectation and reality. The paper concludes that '*The current environmental initiatives and regulation are an opportunity to change the process and achieve better all-round value. But to do so, we all need to become better informed on how buildings really work and where true value needs to be added' (*Way & Bordass, 2005).

The Soft landings framework was produced with acknowledged input from a number of commercial sources including BSRIA (The Building Services Research and Information Association), who are a non-profit making organisation who have commercially marketed their services in implementing the diagnostics of the framework. They have significantly introduced a Building Performance Evaluation which is the process of evaluating the performance of a building with Post Occupancy Evaluation (POE) being one of its major parts. It can be carried out in new, existing and refurbished domestic and non-domestic buildings and it comprises three main areas of focus, firstly what they have termed a forensic walkthrough involving an inspection of building's operation in an attempt to establish whether there are any emerging problems or wasteful operational practices, secondly an energy survey providing a breakdown of energy use in the building by type of consumption e.g. heating, air conditioning, lighting etc. and

thirdly an assessment of occupant satisfaction using the Building User Survey format developed by Bordass and Leaman (Palmer, Terry and Armitage, 2016).

The ‘Forensic walkthrough’ alluded to in the Soft Landings process coincides with the cursory inspections identified in the POE and TBP. Forensic walkthrough, expert walkthrough, etc are terms applied to the initial survey of the building with the word ‘walkthrough’ implying a cursory inspection and this suggests a possible lack of rigour to the process. This could clearly be addressed if the performance evaluation was part of a much more thorough survey process such as a building condition appraisal or a periodic building diagnostics exercise carried out as part of a Facilities Management regime.

Gupta (2006) outlined the results from what he called a ‘learning-by-doing’ approach to the teaching of POE. The assessment uses the same cursory or walkthrough inspection approach but data is gathered on both hard and soft issues of building performance throughout the process which is shown in table 1. This again recognises the significance of the three elements of assessment and how this can produce a well defined set of outcomes to assist in regulating the

POE METHODOLOGY		
EnergyAudit and surveys	Environmental Audit	Occupant Satisfaction
Fuel use (gas, electricity etc)	CO_2 emissions	Thermal comfort
Building Fabric	Environmental initiatives	Air Quality
Space Heating and hot water		
HVAC	Transportation	Daylighting
air conditioning		
ventilation	water efficiency	Background noise
Lighting	Materials	
Appliances/equipment	Recycling	
	Waste Management	
	indoor air quality	
	Temperature	
	lighting levels	

Table 1: Components of POE methodology (Gupta,2006)

performance of the building. The Energy Audit and survey looks at a desktop evaluation process which considers the monthly energy use, the likely performance of the building fabric, the use of furtherspecific energy use to provide heating and hot water, HVAC, lighting and the power used by appliances within the building. This offers very useful information to occupiers as to where to look to make savings and to compare some of this information with the findings in the other two areas, e.g. people being too warm and too much energy being used for heating points to an obvious outcome. the environmental audit analyses the issues in terms of their global, local and internal significance and the occupier survey seeks opinions on the performance of the building in terms of the air quality, temperature, lighting and noise within the building. This approach presents a further distillation of the process incorporating a great deal of triangulation of the results obtained to support theories and recommendations for the improvement of the building. This practical approach can also be seen in the development of a number of commercial methods devised to offer building owners potential savings in running their buildings along with an enhanced asset protection resulting from the identification and resolution of any issues identified.

Since the early 1980s the Facilities Management profession has undergone considerable expansion and has become increasingly relevant to building owners and occupiers. It has enabled occupiers to focus on their core business activities and be more productive whilst the introduction of professional FM staff has allowed them to receive the double benefit of operating more efficiently and maximising the value from their buildings. Douglas J (1996) suggests that there is a link between building performance and FM as illustrated in figure 3. This viewpoint coincides with the current development of the process of continuity between the building procurement and delivery stages with the handover and management of the building. Facilities management is shown here to be the co-ordinating management function that concentrates on the interface between the physical workplace and people. The simplified diagram shows that facilities management has a role to play in supporting organisational effectiveness and also has a clear connectivity in a non-commercial context.

Buildings have a significant role to play in promoting the core business or activity housed within them but they should also improve the core business performance by ensuring that all aspects of the building enclosure create conditions that are conducive to good human performance. In order to be certain that the optimum conditions are being produced an assessment of the most

significant aspects of a building's performance must be carried out. Facilities managers need to have some way of determining the extent to which the buildings under their control affect the performance of the activity contained within them and to what extent the support services need to be tailored to these requirements. Of the three primary branches of building performance indicated in Figure 3, building diagnostics is the most immediately relevant to facilities

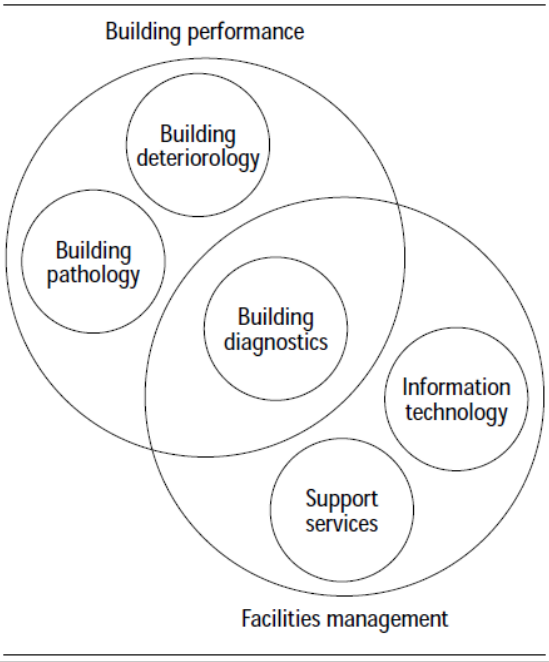


Figure 3. Douglas J (1996) The building performance and Facilities Management interface

management, but the emphasis that Douglas formerly put on building performance being key to the well being and output of the building users seems understated. Building diagnostics has been defined as 'the systematic study and evaluation of building performance' (Preiser, Rabinowitz and White, 1988).

Sassi (2006, p 237) identifies the most widely used method of evaluating building performance to be the Post Occupancy Evaluation and it has been identified that post occupancy monitoring is most informative when it combines physical measurements with personal views of building occupiers. She goes on to identify that the occupiers are not only fundamental to the successful performance of the building but are also an invaluable source of information and knowledge that

can be re-used. A detailed survey with an information gathering exercise from the building users would capture information for assessing how well the building meets the occupier needs and possibly aid the decision making process regarding condition.

Farbstein et al. (1986) surmised that there are four methodological strategies appropriate to assess the interrelationship between building performance and occupier behaviour. These strategies are; evaluation of user satisfaction, attitudes, and behavioural responses to the buildings; analysis of patterns and intensity of use of the buildings; assessment of the physical conditions in the buildings; and monitoring and evaluation of the design and construction management process where a new building, or one about to undergo a major refurbishment is involved.

According to Farbstein, building user satisfaction analysis involves obtaining primary data directly from building users. This can be achieved through the use of questionnaires and interviews to assess users' perceptions, attitudes, and their satisfaction with the buildings. In addition administrative personnel i.e. technical, clerical, and maintenance operatives, similarly, visitors and other interested persons could also be included. The analysis of user satisfaction should focus on major interior and exterior spaces and will address at least four issues.

1. **Satisfactions with and perception of the building use and environmental conditions**, including space utilisation, the fit between activities and the physical setting, energy conscious design and other special features.
2. **The image of the building interior, exterior, and setting**, including scale, form, materials, and finishes.
3. **Safety** including: twenty-four hour use of the building, theft and vandalism, accidents and crimes against persons.
4. **Communication and social interaction** including: multiple levels of occupant communication, the accommodation of small, moderate and large groups and the ability to achieve solitary and small group privacy, (Farbstein et al, 1986).

Although the Farbstein comments are made with building refurbishment or rehabilitation in mind they are extremely relevant and represent what can be said to be important functions of the built environment and amongst those most closely examined.

Building user satisfaction has been shown to frequently highlight problems with buildings that have not been identified by the building condition survey or, more significantly, the building defects or snagging at the completion of new buildings. One or two years in to the life of the building, possibly aligned with the expiry of the building's defects liability period, a POE is conducted and a possible consequence of this would be to result in a long list of minor defects for the contractor to remedy. However there are also cases recorded that have led to major defects and even fundamental floors in the design being detected (Bordass, 2001). Whilst it does not seem unreasonable for a building owners to expect proper remedy for any issues with their new building is has resulted in some reluctance amongst designers to promote the use of the POE. The inevitability of finding fault that is attributable to the design team or the contractor which results in a claim of professional negligence or significant workmanship and materials failure has led to disputes over original performance claims and the reliability of the software being used to determine performance; 'The idea of a post occupancy evaluation is not one which has been welcomed in an Industry where the identification of issues with performance suggests blame and culpability' (Doidge, 2001).

The BPE that offers an assessment of current performance and suitable remedy, does not suffer so much from the possibilities of instigating litigation between the clients and their professional advisors or contractors as the subject buildings would generally not be new-build. The application of the techniques developed through POE are applied to the assessment of existing buildings and used not to identify flaws in the design intentions but to ascertain the building performance in comparison to other similar building types. It can also be used to identify ways of improving the performance in terms of the physical environment created within the building for its particular use and the sustainability of the building overall.

It has been suggested that one of the main barriers preventing the widespread implementation of post-occupancy evaluation is the lack of legislation making some form of POE a mandatory requirement, as in the UK construction Industry non-mandatory proposals are rarely taken seriously. There is also the perception that POE has excessive costs attached to it and if the subject has not been covered at a very early stage there is likely to be a dispute as to who should meet the cost. Another significant reason for a lack of uptake of POE has been attributed to the general conception in the Industry that the work of the design team and the principal contractor

is complete at the point of handover and the method for dealing with any emergent defects is an adhoc process (Stephenson, 2009).

The benefits which can potentially be derived from POE, offer a number of incentives which drive its deployment for many building owners. Jaunzens, Cohen, Watson, Maunsell and Picton (2002) put forward a number of motives behind its use. They suggested that staff time and efficient working gains were available through the provision of appropriate and high quality facilities. That any reduction in discomfort to staff would improve their productivity and increase their motivation. It was also suggested that the POE would provide an ability to prioritise facilities budgets more effectively and to identify and potential system inefficiencies which could be critical to business performance such as poorly ventilated areas having high CO2 concentrations leading to drowsiness, headaches and poor concentration levels of occupiers.

Blyth Gilby and Barlex (2006) identified and listed the short term benefits of POE as being an immediate ability to identify issues and find solutions to problems in buildings, to demonstrate an ability to respond to user needs and to improve space utilisation based on feedback from users and from re-evaluation. A very significant benefit identified by the group was to improve the understanding of implications of change whether it is budget cuts or changes in a working context and an overall improvement in decision making simply based upon holding better quality data on the building.

They also identified medium term benefits of POE as being able to provide a capacity for larger scale building adaptation to organisational change and growth, being able to find new uses for buildings and significantly improving the building owners and occupiers ability to hold their building designers to account for building performance. Longer term benefits of POE were also put forward and included an ability to assess and make long-term improvements in building performance, to have a platform from which to consider improvement in design quality generally and to build a strategic view of their occupancy objectives. This latter ability could enable business and non-commercial organisations such as schools to develop sustainable building occupancy strategies.

Cultural and educational issues have been identified as barriers to the use of POE and BPE as many designers, builders and their project managers do not have a detailed knowledge of building performance as they have no specific training in the techniques of evaluation.

According to Bordass and Leaman, (2005) Designers have no obligation and are not paid to carry out the process. Although there is a responsibility to deliver what has been clearly specified in the contract documents especially where performance is the basis of the requirement.

These are valid reasons for the lack of enthusiasm for using POE techniques to the application of building maintenance and the lack of awareness of the benefits is also a factor as there has been a lack of connectivity with the development and use of POE and BPE with the conventional maintenance and improvement of school buildings.

Cooper (2001) asks the question ‘who is responsible for commissioning and paying for such evaluations and who is professionally responsible for undertaking them’ he asserts that until such questions about ownership are satisfactorily resolved, the development of POE will remain stunted. Client organisations are unlikely to pay for BPE unless the benefits of such evaluations are both evident and add substantial value (Cooper 2001, p 159).

It has been muted that the lack of training and skills within the UK construction workforce in relation to new technology has resulted in the failure of buildings to comply with energy-related regulations (Warren A, 2014). The failure of any part of the building envelope, whether it is in achieving air tightness or preventing moisture ingress or creating excessive cold bridging around openings will inevitably lead to a lowering of the thermal performance of the building. Moisture will in all cases have a detrimental effect on thermal performance of insulation materials from an increase in the thermal conductivity resulting from its presence (Trechse, 1994). It is therefore of great importance to identify defects which lead to moisture ingress or defects having an impact upon the air tightness of the envelope. The impact of the failings of building fabric on the performance of buildings can be very severe and any future building performance appraisals should take full and careful account of the affect of this.

A study that resulted in further developing the standard POE survey and related it more closely to building condition was carried out by Baker (2010) and used to assess the performance of school buildings in California. The study was primarily aimed at providing feedback to designers to better understand the implications of their design decisions but it also offers some clarity of what Baker termed ‘Operations and Maintenance practices’ and recognised building condition as a factor. A simple POE was conducted on a large sample of schools identifying

various trends in the design of school buildings. These trends were found to have positive and negative impacts on the users of the schools.

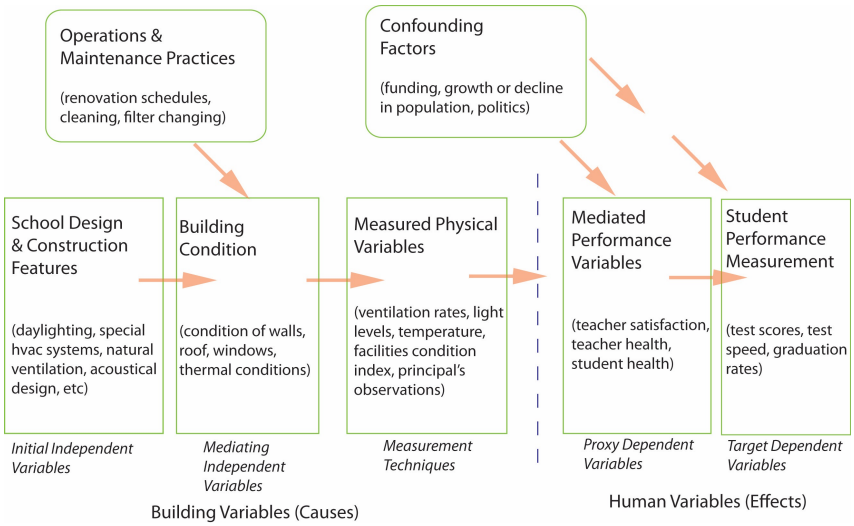


Figure 4. Baker (2010) Proposed Causal Model for the effect of school design on academic outcomes

The exact extent to which building condition affects building performance is often difficult to gauge and although there are some instances where there is a very high dependency there are others where it is not so obvious. The decision on whether to act on a building condition defect or to improve a building performance issue is a prioritisation exercise made possible by the collection of a set of data on the building in a way that enables a comparison to be made. Wheeler and Malekzadeh (2015) developed an integrated POE approach that involved teachers, staff, students and community members. Amongst the benefits that were identified from this study of secondary schools was the prompt identification of building defects and the remedial actions for them, comprehension of the consequences of the decisions made during the design and operation of school facilities, and the rational allocation of maintenance budgets based on the current post-occupancy conditions of school buildings. This however leaves a question as to how all building defects could be captured by the observations associated with POE practice, i.e. the walk-through survey and the conditions identified by the occupier feedback. The

conventional approach to assessing building condition remains a part of the process accompanied by the three sections of the BPE i.e. the energy assessment, the environmental assessment and the occupier feedback.

Armijo, Whitman and Casals (2010) conducted a POE study on eight government schools located in very different climatic zones in Chile. The study evaluated the quality of thermal comfort, visual comfort, acoustical comfort and indoor air quality at 14 different classrooms. The POE utilised several data collection methods, namely walk-through evaluations, questionnaire surveys and in-situ measurements. The study highlighted the performance deficiencies in each of the evaluated schools. The results of the study strongly suggest that natural ventilation is not the optimum solution for the teaching environment especially when located in noisy urban areas, areas with airborne pollution or cold climates. It also found that reliance on teachers to open windows is problematic in maintaining reasonable classroom conditions. A concern over acoustic or thermal discomfort was found to often take priority over that for providing sufficient ventilation and good air quality.

Watson and Thomson (2005, p 130) observed that '*no school building perfectly facilitates stakeholder needs. This is explained by most buildings being designed by an engagement with less than perfect clients, architects and builders who construct for a diverse range of occupants who end up using the building in ways that were only partially predicted'.* This is a factual statement and although suggests that perfection is not an achievable goal, the use of POE as means of improving future building design is still an important outcome. They also highlight the importance of POE in refining information back to designers for the purpose of fine tuning new buildings, demonstrating best value, building stakeholder commitment and most importantly they identified the value of building evaluation methodologies in appraising existing buildings. The POE carried out by Watson and Thompson served to raise awareness about the use of POE as a tool to assess the performance of educational facilities.

What methods should be used? This chapter has examined the large number of techniques that have been used for building evaluation however there are a great many more suggested techniques reported in a review carried out by Baird et al. (1996). This is not necessarily a problem, as the carrying out of any form of structured POE or BPE must provide all of the

building stakeholders with information that they require about performance. It might indicate building condition failures or fundamental flaws in the adopted design strategy (Leaman, 2003) or it may just provide information general information to assist those involved with the facilities management or maintenance that their building is running reasonably well. It offers the possibility to consider the priorities and whether to accept the performance or to consider the cost and added value of improving it. Better quality, more detailed relevant information is the objective of the evaluation combined with the knowledge of how to interpret and use this data. The use of new technology to provide highly tuned evaluation methods and the introduction of these to the industry has been recognised as an important goal but the production of a particular set of relevant techniques has not been the outcome and POE and BPE surveys and the selection of techniques are generally made so that they are appropriate to the building and the client. The next section of this chapter will evaluate the techniques appropriate to Primary school buildings with an emphasis upon what is most relevant to improving learning, most effective in maintaining condition and most economic.

2.02 Evaluation of POE techniques for primary schools

The literature has demonstrated how the use of particular techniques has evolved over a period of more than fifty years from the work in the 1960s to the 1980s where particular aspects of the performance were defined by applying random groups of techniques (Markus et al, 1966, Manning, 1965) to the grouping of techniques into specific fields (Hartkoff, Loftness & Mill, 1986, Preiser & Sharm, 1997, Bordass Leeman & Russyfeldt, 2001, Way & Bordass, 2005). The POE eventually developed into a set of techniques grouped together within suitable fields which enabled a comparison to be made from the measured data and the occupier feedback. These fields of the POE have in recent years become focused upon Energy, Environment and Occupier feedback (Gupta,2006). The next stage of this research makes a critical assessment of the most prevalent techniques within these fields and looks at the appropriateness of the techniques as indicators of performance that can be used for the practical benefit in the maintenance and improvement of primary school buildings. It is the aim of this research to establish what are the most practical means of improving performance and therefore not to include any peripheral issues that have only a limited benefit to the asset management of the schools. A further review of the practicality of the selected techniques is made with input from the Head Teachers and their

staff through the occupier feedback and at the time of the review of the findings for the production of the School Maintenance & Improvement Plans.

The process begins with an acceptance that the three main fields of the POE ie energy, environment and occupier are the essential ingredients that have been derived from the development of POE to date. They have repeatedly been seen as the main areas to have evolved from the earliest work and over time they have become the recognisable platform for the delivery of the POE and therefore a BPCE.

2.021 Energy Assessment

Within the period of the development of POE techniques there has been a strong drive towards greater energy efficiency which has led to a number of evaluative techniques for buildings in use these have been shown to mainly comprise the following selected group.

Overall energy use

The most fundamental question of any building performance exercise is what is the overall energy use and how is it being used. Quantifying the energy use can be carried out by a desktop exercise looking at the monthly fuel consumption for heating and hot water and then to the other use of electrical energy for lighting, HVAC and power usage for the appliances contained within the building (Gupta, 2006). By identifying this and looking at the energy use per m^2 the first basic question to be considered is made by comparison and benchmarking with other similar buildings housing a similar usage. It provides the opportunity to question as to whether there is a significant under or over-performance and if so why is this the case and where is the energy is being used. This type of examination is at the heart of the performance evaluation and can produce results which point to use patterns which can sometimes be easily corrected at low or no cost. It is the first step in the evaluation identifying some practical and easily obtainable savings or pointing to possible malfunctioning of particular M&E installations within the building.

Obtaining accurate energy use data for the building on a monthly basis enables a degree day analysis to be undertaken, this provides a good indicator of the consistency of the energy being used for heating and how responsive the heating installation is to the changing external

temperatures. Whilst this is an approximate measure it does provide an insight in to whether there is an energy efficient response to temperature changes.

Building fabric

One of the most significant influencing factors upon building performance is the building envelope. In many buildings, the energy consumption can be significantly reduced by adopting energy efficiency strategies and this is especially so in primary schools. Due to environmental concerns and the high cost of energy in recent years there has been a renewed interest in building energy efficiency. The purpose of an envelope wall is to offer an enclosure which retains heat, keeps out the weather, provides ventilation, prevents the passage of unwanted noise, allows natural light to enter and enables ventilation ie the maintenance of 'human comfort' (Burberry, 1970,p 17). There are many different types of wall structures used in primary school building from the very early school houses of the nineteenth century such as very thick solid stone walls, cavity walls of varying types, timber framed, and glazed walls etc all of which offer a vast variety of levels of performance. Apart from the most recently constructed primary school buildings the average primary school has undergone a continuous expansion to accommodate the ever changing requirements resulting from increased numbers and changing educational needs (Seabourne, 1971).

The progressively higher standards required from Building Regulations and other legislation has resulted in various types of thermal insulation materials used in conjunction with a wide range of construction types result in voids within the school having different thermal performances. This makes an accurate evaluation of the overall envelope very difficult. The objective was to find easily measurable physical features which could offer an indication of performance and the effect on the occupier and which could be affected by building condition and improvement works. Differing performances across the envelope also result from inconsistent construction quality and varying states of condition and for this reason an attempt to make physical overall measurement of the envelope performance was excluded from this research.

Space heating and hot water

The measurement of the energy use in connection with space heating has been shown to be the most significant area for energy use in primary schools. The baseline energy use can be assessed

by looking at the energy consumption during the summer months when the heating is turned off and this can then be assumed to be approximately constant throughout the teaching year. The identification of energy used in association with heating and hot water is vital as this can then be compared with the actual internal environmental conditions being achieved. In many over simplified assessments of performance the internal environment being achieved, ie. what temperatures are being experienced in the teaching areas, is being overlooked and it is obvious that if the policy of the school is to teach at higher temperatures then the consequence of this will be higher energy use. This obvious fact makes the decision to include an understanding of this comparison an important component for any primary school energy assessment.

Ventilation

The appraisal of the effective ventilation can be made by the monitoring of CO_2 levels in the teaching areas of the school and the decision to carry out a random selection of areas was made in the knowledge that this is an approximate process and may not fully reflect the effectiveness of the ventilation in all teaching areas but offers a sample of up to six teaching areas. In many cases this was an effective measure because of the similarities between the classroom conditions, ie same envelope, same ventilation strategy etc. In the context of energy use the measure is concerned with the energy used in achieving the prevalent ventilation levels. Clearly a good internal air quality is achieved at a cost as this involves greater number of air changes per hour and the associated heat losses in achieving this will be reflected in the energy costs per m^2. For this reason the schools awareness of this is vital and this is an important measure not just to demonstrate what is being achieved and what remedial action may be required but to identify what costs would be involved in achieving the correct standards.

Air conditioning

The use of air conditioning or comfort cooling units in primary schools has often been made following overheating issues in some areas in the summer months and in situations where opening windows and natural or mechanical ventilation methods fail to produce comfortable working summer temperatures. By measuring the energy used in connection with the use of a/c the school can see the full cost of using it and they can then look at measures to restrict its use and also consider alternative solutions, particularly where the summer CO_2 levels in classrooms are high resulting from the lack of fresh air entering the school. Air conditioning is not widely

used in primary schools but its high install, maintenance and energy use make it a significant factor in the assessment of building performance and for this reason it justifies a closer assessment as part of the overall evaluation.

Artificial Lighting

The provision of natural daylighting is generally desirable in all areas of primary schools apart from where glare presents a problem. In many cases the use of sun blinds to restrict glare results in the use of artificial lighting during the day and increases energy use. An assessment of the energy associated with failing to maximise the use of natural light is an important measure for the school and provides an option for installing blinds which prevent glare but use reflected light to create adequate lighting levels. The technological advancement in low energy lighting and the decreasing cost of installing and maintaining such lighting means that the school should be aware of the energy use associated with their current lighting so that a cost comparison can be made for an investment in new lighting and the payback period completely understood. It is also important to measure the existing lighting levels in all areas of the school as failure to meet good standards of lighting has been shown to affect learning levels (Barrett, 2015). There are recommended standards for lighting levels in various areas which can be measured using a light meter. The meter used in this study was Iso-Tech ILM350 handheld digital light meter which was used at desktop height approx 850mm from ground level and at least readings were taken per classroom from a position near the centre of the room. For all other rooms a single measurement was taken from a similar height towards the centre of the room or area, all readings were taken after dark.

Use of appliances and equipment

Increasingly primary school teaching methods rely upon the use of electrically powered technology such as plasma screens, interactive whiteboards, tablet computers, laptop and desktop computers all of which have become strong educational tools for everything from improving hand-to-eye coordination and accessing the internet for information, to learning in an entertaining way. The electrical energy use associated with this equipment together with the school photocopiers, printers and other electrically powered devices can add up to a significant cost to the school and by measuring the individual energy use of all items of equipment and then to examine how they use their equipment to see if savings can be made. This is therefore a

useful exercise even if the collection of the data is time consuming and some of the use times are approximate it provides a basis for more detailed examination of energy use related to appliances and equipment. The assessment also completes the picture of electrical energy use and enables a comparison to be made with overall electricity costs. This comparison demonstrates the accuracy of the process as all electrical use evaluated should match the usage identified in the electricity bill for the school.

2.022 Environmental Assessment

The assessment of the environmental performance of the building within the context of a POE has in many cases involved an environmental impact assessment of the school buildings in three areas; firstly the 'global' aspect of the building on the environment such as CO_2 emissions and the emissions associated with the building use such as the and the effect of the building and its use on the carbon footprint as a whole. This may also look at the sustainable nature of the building in terms of the materials used in its construction, maintenance and improvement. Secondly to look at the 'local' aspect such as water efficiency and waste management etc and finally to assess the actual 'internal' environmental performance in terms of what the energy use is being used to achieve within the building such as the indoor air quality, temperature, acoustic performance and lighting levels etc (Gupta, 2006).

The Total Building Performance methodology devised by Hartkoft et al (1986) also looked at what they termed 'Building Integrity' ie the affect of appearance of the building upon the occupiers and what they also termed 'spatial' issues which involved an analysis of the teaching areas in terms of their layout and such issues as furniture layout and whether there was fixed furniture etc. Farbstein (1986) also endeavoured to add 'building image' issues together with Safety in the use of the building. For the purpose of this study the objective was to identify just those issues that were considered to be most impacting on the performance of the building and the need for more sustainable practices and environmentally sensitive design. A number of issues have been identified in the measurement of the environmental impact of buildings. The most important of these being identified as follows.

Overall CO_2 Emissions

The calculation of the overall CO_2 emissions for the building can be made as a consequence of identifying the entire fossil fuel consumption from the energy assessment. This is also provided within the schools DEC and is clearly something worthy of identifying in greater detail and in conjunction with the specific energy use being measured. The water use also contributes to the CO_2 emissions and although this is not a considerable amount it is simply calculated from the measurement of water use and increases the accuracy of the overall emissions figure. For this reason it was considered to offer a more complete picture and the incentive to look for reductions when compared to comparable primary school types and therefore worthy of inclusion.

Transportation

Gupta (2006) introduces the idea of measuring the CO_2 emissions resulting from the occupiers traveling arrangements and deliveries to and from the building. Whilst this is highly relevant as the schools have an average size of 225 pupils and 30 staff and the emissions created from all of this people movement is likely to be high in comparison to the schools building use CO_2 emissions. The purpose of the exercise of measuring this is to look to find ways to reduce it by encouraging walk or cycle to school and car sharing. It is however a considerable task to carry out the measurement with any accuracy and it will continually change and therefore needs to be monitored to be effective and that requires more resources. It could also be said that the emissions can only be reduced and never completely removed and so it is an activity that provides limited success in reducing emissions whilst using considerable resources. It also has no impact upon the school buildings energy use or the internal environmental conditions. For this reason the calculation of transport CO_2 emissions was not included.

Water Efficiency

The reduction of potable water use has been a focus for schools through the Eco-Schools programme and many other initiatives for some time. The water efficiency of the school offers an opportunity to benchmark the schools use per pupil to ensure that water use is being minimised whilst ensuring that there are no leaks in the system. The water use monitoring can be carried out remotely using smart meters and the data made available to the schools for analysis

and the he benefits are reducing costs and emissions. For this reason the analysis of water use was included in the building performance assessment.

Materials

The measurement of CO_2 emissions in use of materials can extend to a great many activities from buying school paper to constructing a new classroom extension. There is a very large amount of time and resources required to evaluate the carbon content of the schools overall running and this was considered to be a similar situation as transport and considered to be a peripheral activity and excluded. However any sustainability strategy or plan which may be developed by the school would need to consider this issue and develop policy upon the school teaching materials as well as other materials that would be likely to be used throughout the life of the school. This would include new building and the use of materials in carrying out maintenance work such as new windows, doors, roofing, resurfacing of playgrounds etc, all of which would have a considerable impact on the school emissions. The overall purpose of this activity would be in connection with a 'Global' issue and not directly impacting the building performance or likely to produce cost reductions and it was therefore decided to exclude this method from the process.

Recycling and Waste Management

Many schools adopt some form of recycling without actually measuring the overall benefit in any detailed way but simply accepting it as something worthwhile to do and relating their activity to an approximate method of calculating the benefit. The adoption of such policies are made to encourage children to consider the benefits of recycling and raise an awareness of the plight of our planet from using non-recyclable materials and components. The range of recycling processes that could be adopted by primary schools is considerable ranging from paper to metals plastic bottles, batteries, etc and there are a great many guides and publications that are made available for schools on this issue. It was therefore decided to exclude any attempt to measure or recommend any aspect of recycling or the ratio of recycling materials to those considered to be 'waste' as this is a vast and separate subject from the building performance evaluation.

Indoor air quality

Whilst the issue of the energy used in providing ventilation has already been considered, the extent of our knowledge of the effect of teaching children in high CO_2 environments makes this measure an important one. The air quality in classrooms has been shown to have a significant effect upon the occupiers performance across a range of different tasks (Satish et al, 2012). In primary school teaching areas the importance of achieving good ventilation rates has been shown to be impacting upon children's attention levels as much as 5% reduction between working in low levels of CO_2 (1500ppm) compared with high levels (+2500) (Coley & Greaves, 2004).

The inclusion of this activity as a part of the overall measure of performance is therefore very relevant as it offers a possibility for controlling the CO_2 levels and thereby directly influencing learning levels in the teaching areas. The monitoring of CO_2 levels throughout the teaching week demonstrates how CO_2 levels build up and decline throughout each day giving an indication of how well the ventilation reduces the CO_2 levels by allowing external air, which has a concentration of approximately 450-500ppm, to mix with and reduce the CO_2 levels of the internal air.

The measurement involves the use of integrated datalogging devices which record the levels within a classroom of the school every 90 seconds over a period of 2-3 weeks during the winter terms. The data loggers were positioned in representative locations within the classrooms at a height of approx 1.4 to 1.8 m where they were more secure from tampering, away from any radiators or heat sources and windows. The dataloggers (Extech Instruments SD800 CO_2/ humidity/temperature data logger) utilise a dual wavelength NDIR CO_2 sensor and captures data directly to an excel spreadsheet on an SD card. The device has an accuracy of ± 40ppm up to 1000ppm reducing to ±5% between 1000 and 3000ppm and ± 250ppm for readings over 4000ppm. This level of accuracy was considered adequate as the readings were to be used to offer general indicators of ventilation levels not specific CO_2 concentrations. This particular technique was considered to offer a very high value to the process of performance appraisal particularly as the emissions found in many classrooms has been found to be between 2,500ppm and 5,000ppm (Annesi-Maesano, 2012).

Temperature

The recommended temperature for classrooms in the UK is 18°C and 21°C for special needs, low activity levels or very young children (DfES, 2000). It has been shown that when temperatures rise above or below normal comfort levels they become a distraction in a learning environment which reduces academic performance (Haverinen-Shaughnessy & Shaughnessey, 2015). It is therefore important to maintain comfortable temperatures throughout the teaching day which can respond to sudden changes, uncontrolled ventilation etc. In many cases adults and children adapt to small temperature changes but in order to understand the range of temperatures being experienced across each teaching day it is necessary to data log the temperatures. The profile of the temperature recordings over a period of a week during the winter demonstrates how the activities relate to the temperature levels and also how the heating system responds.

An important consequence of continuous monitoring is that during the winter it enables us to look at the rate at which heat leaves the building when all of the occupants have gone home and the performance of the boiler ie when the frost stat activates and at what time in the morning it begins to produce heat and how long it takes to reach the correct temperature. All of this data can be used to assess the efficiency with which the energy is being used and the effectiveness of the heating system. This is particularly useful as it can help explain high or low energy use figures form the energy assessment by showing the actual classroom temperatures and how much energy is being used to maintain the temperatures. For this reason temperature monitoring was considered to be an important part of the building performance assessment.

Daylighting levels

Within the Energy field of the assessment process there is a justified approach for accurately assessing the lighting performance and the load for artificial lighting in the interests of improving the lighting levels and the energy efficiency in attaining the improved levels. In this part of the Evaluation the lighting levels are measured and an assessment is made of how well natural lighting is being deployed and how the amount of natural daylight could be increased.

In some POEs this section is referred to as daylight and view and also considers the views or aspect visible from the building. Natural daylight is generally thought of as being preferable to using artificial lighting as the energy usage is less and natural light has been found to linked with an improvement in academic performance where window to floor area rations for classrooms

were higher (Maesano & Anessai-Maesano, 2015). However natural daylight is not as consistent as artificial lighting and direct sunlight produces glare. The most desirable situation may be a combination involving the use of artificial lighting and sun blinds to accommodate the changing levels of natural daylighting whilst maximising its use in maintaining recommended design illuminance (Winterbottom & Wilkins, 2009). Measuring lighting levels in classrooms and creating lighting contour diagrams with simulation software to show the extent of the natural lighting entering the building has been carried out as part of a POE but for the purpose of this exercise it was considered unnecessary to include this technique. Whilst the information provided by this sort of exercise is useful, the school could introduce a policy for using natural daylight in any particular way without actually measuring it. The close scrutiny of how natural daylight is used could lead to energy cost reductions, however, the time and resources required to produce a detailed study was considered to be beyond the scope of this study. The measurement and checking of artificial lighting levels in classrooms and the comparison with using low energy lighting is being made as part of the energy audit.

Acoustic performance

Noise levels in school buildings are generally made up from a number of sources but mainly internal noise generated in the classroom, other internal noise from outside the classroom, e.g. adjacent classrooms and corridors, noise from M&E equipment and external noise such as playground noise or traffic. The measurement of the ability of the school buildings to minimise all of these sources is important as noise levels in classrooms have been shown to be a critical factor in the academic achievement of children (Picard & Bradley, 2001).

Most acoustic issues with school building arise as a result of a perceived problem by the occupants, followed by some investigative measurements and recommended remedial measures. However like many other distracting issues the occupiers usually take actions to resolve the issue by directly affecting changes without looking to make adjustment to improve the building performance. According to Barrett et al (2015) *'although sound does seem to have some effect on learning, in our multilevel modelling (MLM) it was competed out in importance by other factors'*. A significant amount of time and resources would be required to carry out the investigation of all aspects of acoustic performance including taking readings in classrooms and analysing the results and recommending possibly extensive and costly solutions to solve

problems previously unperceived. It was therefore considered that although the acoustic performance of primary school buildings is important it is worthy of a separate study and was too extensive to be included in this research. However it was clearly something that would be worthy of inclusion in the occupier feedback questionnaire as this would enable specific issues to be highlighted so that the problems could be investigated and proposals made to resolve them.

2.023 Occupier Feedback

The use of occupier questionnaires to gain an understanding of the users views on the performance of a building has been shown to be an effective means of highlighting many types of problematic situations. The many survey formats have been used generally proved that the use of simple and direct questioning has resulted in the most useful feedback (Sassi, 2012). The main focus of occupier surveys has generally been Thermal Comfort, Air Quality, Lighting (artificial and natural) and noise levels (Gupta, 2006). One of the most regularly used survey formats is the Building User Survey (BUS) developed by Leeman and Bordass (2005). This survey has become an accepted standard for the exercise in both its content and its layout. The format uses the likert scale to evaluate occupiers opinions and provides the respondent with the opportunity to comment where they feel strongly enough to do so. The content of the questionnaire will now be critically examined in order that the question is fully justified to be included in the performance evaluation.

Background of Respondent

A few simple details about the respondent can be helpful in identifying their role and where in the building they work. It is also relevant to gain an understanding of how long they have worked in the building and how many hours per day and how many days per week. It may be worth looking at the data only through the surveys of teachers or teachers who have worked in the school for over 3 years, etc and so these simple questions add value and should be included.

The Building overall

To obtain a little feedback on the individuals overall impression of the building at this stage gives an insight as to what their feelings are for their workplace and this can be compared with

the same question after the more detailed questions at the end of the questionaire. A question about whether the facilities meet the needs of the respondent also makes a pre-evaluative questions attempt to gage their general feelings about the building. It is an interesting comparison between how people feel before the detailed questions ask them how they feel about particular aspects of performance and how they feel about the building after these detailed questions. It is a measure of the respondents general acceptance of the conditions within the building and how they have subconsciously adapted to them. General questions on the image of the building personal safety further paint the general picture of the respondents overall satisfaction.

It was considered worthwhile to add two further questions to this section concerning issues which are commonly inadequate i.e. the issue of smaller teaching rooms for intervention and the provision of suitable storage areas. These were included purely for the purpose of giving the teaching staff the opportunity to comment enabling the Head Teacher to see the overall position on these two contentious issues. This is also the same for the questions on the work area which are simple comments about the space provided and the furniture. These questions are not typically included in the BUS format but have been looked at in other POEs such as Hartkoft Loftness & Mill (1986).

Thermal Comfort

The occupier surveys attempt to gather a very condensed set of data on the general experiences of the occupiers during firstly the winter period and then the summer. There are two question concerning the temperature and the air quality and they are the same for both summer and winter.In the temperature question the respondent is invited to comment upon whether they are comfortable, too hot or too cold and to indicate if the temperature is changeable through the working day. The air quality in both summer and winter asks the respondent if the air is draughty or still, dry or humid and fresh or stuffy. These questions are taken from the BUS format which has been widely used and give a good indication of the heating system and summer cooling strategy is working. It was decided that no effort would be made to take any physical measurements to determine the thermal comfort as this would be time consuming and have no bearing on the feedback from the occupiers. The results from the logging of temperatures,

ventilation and relative humidity can be compared to the staff responses and enable decisions to be made as to whether further investing or remedial measures are required.

Noise levels

The issue of measuring noise levels has been previously addressed and questions about noises levels in the questionnaire offer the respondent the chance to make comment upon the noise levels in their area. If there are a great many comments about noise levels then clearly something more needs to be done to investigate why this is so but there is no intention in this research to evaluate the acoustic performance of the building beyond this simple set of questions. The questions refer to noises levels overall and to whether they are satisfactory or not . There are also questions about noise levels form neighbouring rooms, outside and plant and equipment which has been adopted from the BUS format.

Lighting

The feedback requested for the lighting in the respondents working area simply asks if the lighting level is satisfactory and if there is too little or too much natural light or too much or too little artificial lighting. This question offers a direct comparison with the measurements and the calculations made earlier of the lighting levels and energy use in achieving those levels. The responses may not always correlate with areas of poor lighting as people who are working in gradually deteriorating light levels may adjust to them and become accustomed to them. A little further investigation and discussion with the respondent can clarify this sort of situation.

Health

In many occupier feedback surveys the questioning around how healthy the occupier feels in their time in the building can be quite detailed (Leeman, 2005). For the purpose of this survey it was decided to invite one overall question enquiring as to whether the building makes the respondent more healthy or less healthy on a sliding scale of one to seven. With a large number of responses this single question gives an indication of the general feeling about how healthy the building is without asking more detailed questions about headaches, dryness to the nose and throat , etc.

Personal Control

It was considered necessary to follow the method used in the BUS format in that a series of questions are asked about the level of control the respondent has over heating, cooling, ventilation, lighting and background noise. In each case the respondent scores their level of control on the likert scale of one (no control) to seven (full control) there is also a box to be ticked if the respondent thinks that it is important that they have control over this aspect.

Overall Design

As a conclusion to the survey a final question is made of the overall design of the building in suiting the respondents needs this is the same question that was asked at the start of the survey and this offers a more considered response. Over a large sample the comparison with the average initial response and the average final response offers an indication of the effect the survey questions have had on the respondent and to what extent they might feel differently about the building when as to take into account all the ways in which the building makes them feel. For this reason it was considered worth gathering this view.

The Occupier Feedback Questionnaire was only finely tailored from the BUS format and it is clear that very simple and short surveys do obtain better responses form occupiers (Sassi, 2005). The final consideration as to what techniques and methods should be retained in the proposed evaluation was made, firstly, on, what was it that we really needed to know, how the data gathered could cross-fertilise and support other findings, and most importantly, how all of the data would enhance the asset management and the maintenance management of the building.
The survey used in the research for the proposed BPCE will also be reviewed and commented upon in the Head Teacher interviews.

2.03 Current practice in school building maintenance and asset management

In the latter half of the nineteenth century, politicians in Britain finally decided that all children should be educated and the 1870 Elementary Education Act (The Forster Act) was passed. This implemented the recommendations of the 1861 Newcastle Report, which had urged the state to provide 'sound and cheap' elementary schools for children aged 5-13. The Hadows Committee proposal for the division of schooling into the primary and secondary phases was accepted by the government in 1928, though primary schools were only formally established after the Second World War in the wake of the 1944 Education Act and it would be the mid 1960s before all children were educated in separate primary schools (Guillard 1997).

All children in England between the ages of 5 and 11 are now entitled to a free place at a state Primary school. Most state schools have to follow the national curriculum and these include community schools which are controlled by the local council and not influenced by business or religious groups. Foundation schools which have more freedom to change the way they do things than community schools and Academies which are run by a governing body, independent from the local council and they can follow a different curriculum. Academies are effectively publicly funded independent schools, they do not have to follow the national curriculum and can set their own term times. They still have to follow the same rules on admissions, special educational needs and exclusions as other state schools. Academies get their funding direct from the government, not the local council and they are run by an academy trust which employs the staff directly.

Free schools are funded by the government but are not run by the local council. They have even more control over how they do things. Free schools can set their own pay and conditions for staff change the length of school terms and the school day and they do not have to follow the national curriculum. Faith schools can be different kinds of schools, e.g., voluntary aided schools, free schools, academies etc, but are associated with a particular religion. They are mostly run like other state schools. They have to follow the national curriculum except for religious studies, where they are free to only teach about their own religion. The admissions criteria and staffing policies may be different too, although anyone can apply for a place. Private schools (also known as ‘independent schools’) charge fees to attend instead of being funded by

the government. Pupils don't have to follow the national curriculum, all private schools must be registered with the government and are inspected regularly.

This array of organisational types has produced a variety of building maintenance and asset management perspectives and strategies which has also resulted in a considerably variable level of successes resulting in a nationwide estate which is in need of refurbishment and improvement works beyond the scope of the general Government funding. This has been the case for some considerable time in the history of the Primary School as The School Building Survey of 1962 and the Plowden Report of 1967 both reported upon defective and inappropriate school premises requiring what was then a huge investment of over £70 million to put right (Seabourne, 1971, p7). The educational building boom of the 1960s and 70s produced a great many more problems than it solved when the use of non-durable and inadequately researched materials, poor detailing and lax supervision of construction site practices led to a critical situation by the mid 1980s (Landau, 1983).

Since that time the UK government has introduced a number of incentives to support the construction, improvement and maintenance of school buildings, the latest being the Priority School Building Programme where they have attempted to provide the most needy schools with funding for major refurbishment works. In England the Government has undertaken the Property Data Survey Programme to assess the condition and priority of building maintenance work and to establish better and fairer ways of distributing capital funding. This vastly expensive exercise was considered necessary because of the lack of quality up to date information on the schools building condition across the country. The initiative has also extended to publishing information on how the bodies responsible for the maintenance of school buildings e.g. local Authorities, multi academy Trusts etc have used their funding in an attempt to make these bodies more accountable to local people. (James, 2011)

Today there are over 21,000 such schools in the UK that are geographically located within the centre of almost all British communities and can often be seen as an important part of the central hub of these communities. The effect of the building performance of the primary school can be said to impact upon the lives of the children who are taught within them and the larger community who see the primary school as a reflection of the importance of primary education of the community that it serves (Shuayb and O'Donnell, 2008, p7).

The 1988 Education Reform Act brought about significant changes to education in England and Wales and it introduced local management for schools (LMS) thereby transferring responsibility for a school's day-to-day expenditure to its head teacher and governors. The local education authority was allowed to retain certain items of expenditure but the situation resulted in the responsibility for repairs and maintenance being shared between the LEA and each individual school. Under this framework schools could move funds between budget headings, leading to frequent redirection of funds allocated for maintenance (Chanter & Swallow, 2008, p41).

Sebastian James's independent Review of Education Capital published in April 2011 aimed to identify how future spending on school buildings and equipment could provide good value for money. The Report found that; '*Local Authorities do not appear to have set consistent parameters for the use of the funding available for maintenance at school level'*. Indeed, there is anecdotal evidence that suggests many schools adopt, at best, a reactive maintenance approach rather than investing more in planned, preventative maintenance. Ultimately this lack of a standard process results in a relatively high funding requirement nationally, with virtually no economies of scale available, services of greatly varying quality, failure to deliver value for money solutions, limited and ultimately ineffective management of the national school estate's maintenance needs, with decay of the estate that eventually needs addressing at higher cost and occasional emergencies, where a building fails or is deemed unsafe, with loss of teaching and learning time (James,2011).

The report identified that Devolved Formula Capital (DFC) contributions provide a modest capital allocation for each school to support higher-cost maintenance (for example, the replacement of major components such as roofs, windows and boilers that are approaching the end of their lifecycle). It suggested that this was in principle a good idea although raised the very important issue that the current (broadly) per-pupil allocation of funds for small works and maintenance is inefficient. Each school gets an allocation on a national formula therefore funding is being allocated to schools no matter what the actual requirement is for that school. The funding allocated can also be used on a wide range of expenditure including, for example, ICT and minibuses, when building condition need might actually be more important (James, 2011).

The Review went on to recommend that future aims should seek to adopt a more strategic and planned approach to the procurement of maintenance and lifecycle for the school. This should be

informed by accurate condition data and seek to reduce the level of expenditure on reactive maintenance to allow greater investment in planned preventative maintenance and lifecycle replacement.

It can be established from this that there is a serious problem with the quality of the current methods being adopted and the consistency of approach across the organisations responsible for school maintenance across the UK. It is also very unlikely that even the best managed bodies are considering the provision and maintenance of a high quality teaching environment for both staff and pupils as this is not mentioned within the report.

In the 1970s it was considered that light was the most important environmental input, after food and water, in controlling bodily functions (Wurtman, 1975). Lights of different colours affect blood pressure, pulse, respiration rates, brain activity, and biorhythms. Full-spectrum light, required to influence the pineal gland's synthesis of melatonin, which in turn helps determine the body's output of the neurotransmitter serotonin, is critical to a child's health and development (Ott, 1973). Although the emphasis may have changed and a more detailed consideration given to other climatic impacts upon teaching areas there is little doubt that a well designed and maintained environment can help stimulate and support teaching, whereas a poorly designed and maintained school can actually inhibit learning (Kliment, 2001). The effect of the physical school environment on teaching and learning has been studied for many years in order to predict and determine the positive or negative impact of these parameters on pupils' learning. Nonetheless, current school-building designs still result in poor indoor air quality, inadequate lighting, noise nuisance, bad acoustics and functional pedagogical impairments. For years, poor indoor environmental quality (IEQ) has impeded improvements to pupils' performance and harmed pupils' well-being, behaviour and health (De Vrieze & Moll, 2015).

Environmental experiences in childhood have been shown to be influential throughout life; therefore, the way a school is designed and built and the maintenance of a good teaching environment can influence student learning and their lives beyond primary education (David and Weinstein, 1987). A number of very detailed recent studies (Housley, 1997; Fleming and Storr, 1999; Amaratunga and Baldry, 2000; Price, Matzdorf, Smith and Agahi, 2003; Green and Turrell, 2005; Coley & Greaves, 2005, Leung and Fung, 2005; Wong, Fellows and Liu, 2007;

Fianchini, 2007 and Lavy and Bilbo, 2009, Barratt and Zhang, 2012) have provided evidence that there are positive correlations between the performance of educational buildings and the quality of education provided. Research has also shown that increased classroom temperatures (Mendell & Heath, 2005; Wargocki & Wyon, 2007) and low ventilation rates (Bako'-Biro´, Clements-Croome, Kochhar, Awbi, & Williams, 2012) can have a negative impact on the schoolwork performance and health of children.

There is little evidence that the findings of this research is filtering down into practice and influencing what strategy should be adopted for the maintenance of Primary school buildings. A considerable amount of conventional good practice guidance have been issued by the Department for Education such as the Design Note 40: Maintenance and Renewal in Educational Buildings 1985 where premises types were identified and work priorities graded from 1 to 8 (DfEE, 1985). The Methodology of Building Condition surveys, 1993 introduced a simplified priority grading but also identified H&S issues and legal compliance priorities.

In attempting to define a Building Condition Survey it could be 'The collection of data about the condition of a building, part of a building, estate or portfolio, assessing how that condition compares to a pre-determined standard, to identify any actions necessary to achieve that standard now, and maintain it there over a specified time horizon, the purpose being to support management decision making (RICS, 1997). This definition contrasts with an earlier definition which states in simple terms; 'a formal and systematic appraisal of the condition of an item in respect of its ability to perform its required function' (BSI, 1993)

The RICS stock condition surveys originally produced by the Royal Institution of Chartered Surveyors *Stock Condition Survey Working Group in 1997* and its many subsequent revisions and updates identified a number of what it refers to as 'drivers' which prompt organisations to carry out stock condition surveys and notably included were Best value in planned maintenance, Due diligence and forward planning in the UK context of Private Finance Initiative (PFI) and Public Private Partnerships (PPP) projects, Energy efficiency and conservation, the need to evaluate and improve upon sustainability, information to manage the demands of users or occupiers and to provide information for benchmarking both reference data and comparative data (RICS, 2002). This would appear to be an early acknowledgement that energy conservation

and sustainability issues are an important part of the rationale for carrying out condition surveys and that this information, together with feedback from occupiers and users, could direct decisions on planned works.

Perhaps the most commonly applied directive appeared first in Asset Management Plans, section 3 Condition Assessment, 1999 where a process was devised for capturing condition in terms of its condition and the priority for carrying out the works. This simplified approach also reduced the condition grading to an A-D rating where A was ‘good, performing as intended and operating efficiently’ to D ‘Bad, life expired and serious risk of imminent failure’. Each item was also given a priority grading of 1-4 where 1 ‘required urgent works and risked closure of the premises, a high H&S risk or serious breach of legislation’ and 4 identified ‘the works as being long term and beyond the 5 year planning period’ (DfEE, 2000).

The RICS property asset management Guidelines publication 2012 provided direction to those involved with public sector property asset management and explains what is involved and the benefits which will accrue in terms of reduced operating costs, better quality accommodation, more productive staff and satisfied customers. The Guidelines were produced to assist managers in formulating a property asset management plan, delivering a portfolio of space in accordance with that plan and, thereafter, tracking the post-occupational results of the plan. The Guidelines were intended to assist managers establishing a property asset management function, assessing the necessary resources and structures, considering data collection and management and designing the programme delivery process. (RICS, 2012)

In 2014 the Property Data Survey Programme was carried out by on approximately 19,000 schools in England (PDSP). It was developed to provide a cost-effective method of obtaining consistent condition data for the purpose of future financial planning for the upkeep of the schools estate. The surveys were more high-level and less intrusive than traditional full Building Condition and Compliance Surveys that local authorities, trusts, voluntary-aided (VA) bodies and education establishments use and excluded any assessment with regards to sufficiency, suitability and compliance considerations. What the programme showed was in Line with the James Review that there was a huge inconsistency in the existing data on schools and very wide range of standards of maintenance across England (DoE, 2014).

2.04 Summary

The term Building Performance Evaluation has been used in a number of contexts and the scope of it's meaning appears to be broad and sometimes unclear. The interpretation of the term as an holistic overview of the performance of the entire process of building procurement as described by Preiser and Schramm (2005) in their 'Conceptual framework for building performance evaluation' is contrasted with the use of the term to describe the actual evaluation of the performance of a particular building in use. The latter has been evolved from the development of the POE from the 1950s and the term BPE has been used where the 'post occupancy' designation has been seen to be inappropriate. This has frequently been the case where a building is much older than the usual one to two year period for which POE would be carried out. BPE is now the term frequently used for performance assessments of existing buildings. It is this assessment by the use of specific measurements and their comparison to known performance benchmarks, the environmental assessment and the building user feedback that is the focus of this thesis.

The content of the POE and BPE has evolved into something much more bespoke to the requirements of the client and their specific needs to understand particular performance issues and this would appear to be a possible future direction in view of the economic constraints upon carrying out the full evaluation process. What is clear from the literature review is that the techniques that have evolved through the use and development of the POE and the BPE are proving to be very useful in identifying and to some extent quantifying the problems with the subject buildings. Despite the terminology being a little confusing what has been defined by feedback from the stakeholders in the process is a taxonomy of BPE techniques and their precise objectives. The question as to what the content of a concisely tailored BPE would comprise seems to be defined by an increasing knowledge of what a BPE can identify and the extent to which these issues might be critical to the building users activities. If the many individual methods of analysis and diagnosis for any given part remains consistent it would allow a highly developed suite of techniques to be developed which would enable comparisons to be drawn from the results across similar user or building types.

A BPE for Primary School buildings has been shown to be of great assistance to the stakeholders and the occupiers in providing better quality information in order for them to make operational and asset management decisions. A great deal of the literature has shown how the BPE has

enabled building condition issues to be identified by the analysis of the data and by conducting a cursory walk-through inspection of the building. There is also evidence in the literature to suggest that there is a strong link between the building condition and building performance. The BPE has been shown to provide answers about what stakeholders do not know about their buildings but which can assist in all aspects of the day-to-day running of the school buildings, planned building maintenance and guiding decisions for improvement and refurbishment works.

The BPE has the potential to offer a detailed understanding of the specific performance of the built environment and to guide the way to providing solutions to the existing problems resulting in high energy use, CO_2 emissions and the discomfort and under-performance of building occupants. This is particularly relevant for primary schools as the improved performance of children at this stage of their education has been identified as of being of very high importance.

This progress with the development of POE and BPE techniques leads us now to the second part of the literature review and the examination of the current practices and methods being used in the management of Primary school building stock and the historical development of these processes.

The numerous institutional variations for primary schools and their many different funding arrangements no doubt give rise to a variety of property strategies being applied to the upkeep of the school buildings. There is clearly a history of data collection which due to the several different methods and priorities deployed will no doubt result in differing or even conflicting information. The basic requirement for school survey data is to allow the budget holder to make informed decisions on what is required and in what order to tackle the works. This requires a clear set of perogatives to be applied so that the works are carried out in with the highest priority first (as there would no doubt be far more work required than there is funding to carry out) and therefore legislative requirements and H&S issues are likely to be first. The aesthetic improvements are therefore very often delayed for another financial year. Where this is not the case and surplus funding is available for works beyond the urgent priorities then it is important that budget holders can make informed decisions about the need to redecorate or renew floor finishes with the need to improve air quality or investigate high humidity problems.

It is with this in mind that consideration should be given to the strategy to be adopted in carrying out the research that will address this problem and look to find and validate solutions that offer

something to working practices. With regard to the investigation carried out so far it would appear that any additional measurements or applied techniques will be work that requires an increase in the time and resources to complete. The next stages of this research will examine the possibility that the additional work required would be worthwhile and if it could result in making energy savings and possibly lead to a reduction in the work involved in completing the condition appraisal. The concern of the senior property managers within the authority is that the condition surveys are, in almost all instances, capturing work that will not be completed as a result of budget restrictions and prioritisation. This presents an opportunity to look also at the merits of removing some elements of the survey data and leaving these to the subjective appraisal of the head teachers and their property advisors. The complete overview of the process surrounding the use of a BPCE as well as the actual content of the BPCE in terms of what techniques should be used is therefore a key requirement of the adopted research strategy which will now be considered.

3.00 Research Design and Methods

3.01 Research Methodology

The term Research Philosophy refers to the development of knowledge and the nature of knowledge (Saunders et al, 2003). There are three major ways of thinking about research philosophy; epistemology, ontology and axiology. Epistemology is a pivotal issue in any form of research and addresses the claim of 'how we know' that what we claim about the phenomenon we are observing is warranted. In other words what is our theory of truth (Gill & Johnson, 1991, p191). Ontology is a branch of Philosophy dealing with the essence of phenomena and the nature of their existence. To consider the ontological existence of something is to often ask whether it is real or illusory. This is in effect questioning whether or not the phenomenon that we are interested in actually exists independently of our knowing and perceiving it or is what we see and take to be real a creation of these acts of knowing and perceiving? Ontology is primarily concerned with the illumination of the components of social reality; what exists, what it looks like, the parts that form it and how they interact with each other. Axiology is a branch of philosophy that studies judgments about value. Although this may include values we possess in the fields of aesthetics and ethics, it is also very relevant in the process of social enquiry. Heron (1996) argues that our values are the guiding reason of all human action. He further argues that researchers demonstrate axiological skill by being able to articulate their values as a basis for making judgements about what research they are conducting and how they go about doing it.

In considering what methodology would be most appropriate for this research it was first necessary to consider what methodology actually is. It has been identified as referring to the principals and procedures of logical thought processes applied to a scientific investigation (Fellows & Liu, 1997 p 21). This definition seems to suggest that methodology is a fairly narrow set of principles and procedures that logically fit a particular type of investigation. Methodology has also been defined as 'the overall approach to the research process from the theoretical underpinning to the collection and analysis of data' (Hussey & Hussey, 1997, p54). According to Wilson (2001, p6) the nearest equivalent phrase is 'a structured approach' requiring careful selection in terms of the application to which it is to be put and the structure itself. He goes on to say that 'a particular methodology is a set of guidelines which stimulate the intellectual process

of analysis'. The idea that the methodology could stimulate the process of analysis is an appealing one and would be clearly beneficial were it found to be a reasonable expectation. In trying to answer this latter question it would be necessary to identify an approach which draws out and stimulates deeper thinking and evaluation and this was decided to be a laudable goal.

In considering a suitable methodology it has been suggested that the researcher should look for and clearly identify a research gap from a review of the literature and consider the nature of the research problem involved in investigating the issue. Following on from this consideration is to be given as to how the underpinning theory gathered from the literature informs the methodology. For example, have certain factors been identified that need testing to verify their existence? have certain questions been raised that need answering? or has a specific problem been identified that needs to be explored? (Ahmed et al, 2016).

In considering the question of how to assess the relevance and value of particular research methodologies it it important to first review the research questions, how those questions are to be investigated and how we evaluate the outputs of the research. All of these will vary according to our underlying epistemological commitment which is a key feature of our understanding and which influences how we make sense of things, (Johnson and Duberley, 2000). For this research the questions are centred upon the interpretation of phenomena in their natural settings and attempts to make sense of them in terms of the experiences and meanings people bring to these settings. For example what interpretations can be made from considering the impact of applying POE techniques to a conventional asset management approach? The orientation of this research uses an inductive approach to generate theories and it relies on individual interpretation of what constitutes social reality whilst accepting that our perception of social reality is constantly changing. The type of data collected is both numerical and subjective but essentially opinions from interviews and from surveys and although some measurements and assessment methods are required of internal environmental conditions and energy use etc, this type of activity suggests that the research is generally qualitative by nature (Bryman, 2004, p19-20). According to Denzin and Lincoln (1994), qualitative research focuses on interpretation of phenomena in their natural settings to make sense in terms of the meanings people bring to these settings. The type of research being carried out is exploratory in nature and looks at the experience of all of the parties to obtain a view of what is happening and to establish if the outcomes are what is actually

required. The emphasis is upon experience rather than the established views of what constitutes good practice for its source of knowledge. This strongly suggests that the philosophical position of this study is to draw on a variety of perspectives to determine what can be regarded as legitimate knowledge. The overall objective of this research is to examine existing practical processes and to consider how these may be combined to better serve a particular type of buildings. The problem clearly exists independently in a real world situation where the truth is created by meanings and experiences in a given context. This tends to suggest that the epistemological stance is Pragmatism and this would naturally lead to an emic epistemology of carrying out the research from a position within the problem situation.

Knowledge is always relative to the interests at large in culture and so there is no such thing as timeless universal knowledge only knowledge made or produced for specific purposes at particular times (Rorty, 1991, p23). Whilst the postmodernist view seems to suggest that the pursuit of absolute knowledge is futile and that everything is simply a matter of opinion, it valuably recognises that knowledge is not separate form the worlds in which people encounter things and the historical context. It affirms that knowledge is not a detached matrix of concepts and ideas but is embedded in real lives and is an expression of the worlds in which people live and work, (Knight and Ruddock, 2008).

The Critical Realist stance draws upon Pragmatism and Marxist traditions by developing an alternative approach to truth called ‘Practical Adequacy’ (Sayer, 1992, pp 69 - 70). Here Sayer asserts that to be practically adequate knowledge must generate expectations about the world and about the results of our actions that are actually realised. These expectations become realised because of the nature and content of the material interventions and although the nature of human behaviour does not uniquely determine the content of human knowledge it does determine their practical possibilities for us.

A potentially suitable methodology which could be aligned with the proposed research is ethnography, this approach generally demands a less active intrusion by the researcher and has its roots in anthropology. Ethnographers study people in their natural setting and seek to document that world in terms of the behaviour of the people in it and the theory is often generated rather than solely tested (Seale, 2012, p248). The researcher becomes part of the group

under study and observes peoples behaviours or more specifically their culture, it is about the researcher trying to discover the shared systems of meanings and interpretations deployed by a specific group of people (Gill & Johnson, 1991, p154). Ethnocentrism makes strong reference to the practice of judging the standards of a societal group by reference to known standards. This type of research is predominantly practiced where the researcher is entirely alien to the culture under scrutiny and it was also considered to lack specificity. The basis of this research is to understand a very specific field of behaviour and to do so from the position of an insider. It is more focused upon behaviours and processes and the desired endpoint of this research was to identify a theory or process for evaluating Primary school buildings not to make any broad cultural observations about those involved.

Whenever opinions are sought from a group of participants in a process the obvious way to capture opinion is by use of some form of survey. This research approach occupies a position somewhere between ethnography and experimental research (Gill & Johnson, 2010, p 123). Surveys operate on the basis of statistical sampling from highly structured questionnaires to highly unstructured interviews they attempt to gain statistical validity. Analytic surveys attempt to test a theory by structuring the research around dependent, independent and extraneous variables whilst a descriptive survey is concerned with addressing the particular characteristics of a specific population of subjects for comparative purposes. The control of these variables is achieved, not through the use of physical controls as in experimental research but through the use of statistical techniques thus failure to identify all extraneous variables will have serious consequences on the internal validity of the findings (Watt and Van der Berg, 2002). This issue makes the conceptualisation of the research an important factor from the outset. Survey research has a poor ecological validity i.e. the extent to which conclusions drawn from the research might be generalised to social contexts other than those from which the data have been collected. The use of the survey in this research was considered to be a means of gathering data to reflect the overall opinions of the user occupiers and to compare this with the findings from the proposed building performance measurement techniques. It was considered important for the occupiers, mainly teaching staff, to be able to express their opinions around the subject matter of the questions.

The research to be conducted in this study attempts to produce theories concerning the behaviour of the participants in a particular context. This could be achieved by using an experimental or

quasi-experimental research methodology to look at the relationships of variables and to produce hypothesised events. This experimental style of research is best suited to 'bounded' problems or issues in which the variables involved are clearly identified (Gill and Johnson, 1971, p71). Usually experiments are carried out by holding all except one of the variables constant and examining the effect on a dependent variable. The dependent variable could be an observation or actual behaviour, thoughts or opinions (Robson, 2002 , pp133-139). This research would not particularly suit experimental research design because of the difficulty in manipulating the behaviour of the participants so as to construct a social experiment of some kind. Also a high number of variables are present in the research i.e. wide range of questions and categories of interviewee and the risk of confound variance occurring was considered to be unacceptably high.

A quasi-experiment is a research design involving an experimental approach but where random assignment to dependent and independent groups has not been used (Campbell and Stanley, 1963 in Robson 2002 p133). Here the researcher attempts to identify people who have experienced the notional experimental treatment and the attempt is made to compare their consequent behaviour with as similar a group as possible who have not experienced the phenomenon. It was found to be difficult to fit the proposed research questions and the objectives of this research into an experimental format able to produce valid results.

Another possible route for this research is to follow that of Action Research which would clearly fit with research that involves a process of systematically collecting data about an ongoing system relative to some objective, goal or need of that system. Feeding back this data into the system and then taking action by altering selected variables based upon both data and hypotheses and evaluating the results of the actions by collecting more data (French and Bell in Gill and Jonson, 1991 p95-96). This involves the research actively and intentionally trying to effect a change to a system. Knowledge is used to effect the change which creates knowledge about the process of change and the consequences of the change (as well as the change itself), (Lewin 1946). In programmes of action research the usual cycle of scientific research (problem definition – design – hypothesis – experiment – data collection – analysis – interpretation) is modified slightly by purpose of action rather than theoretical bases to become , (research question – diagnosis – plan – intervention – evaluation) , (Fellows and Liu, 1997).

Improvement and involvement are central to Action Research methodology, the improvement of a practice of some kind and the improvement of the understanding of the practice followed by

the improvement of the situation in which the practice takes place (Robson, 1993, p215). It is designed to test and suggest solutions to particular problems and falls within the applied research category. The process of detecting the problems and alternative courses of action may lie within the category of basic research. Action Research could be seen as a possible means of examining the research findings and the changes to the system put forward could then be observed where they were taken up and implemented. The nature of this research is that it is exploratory and evaluative, requiring a reflective process followed by proposed corrective action and appraisal. However, for this research it would be difficult to predict what interventions could take place and over what time scale. This presents a problem as the research needs intervention and re-evaluation, a change process to focus upon in order to offer a viable methodology.

However within the realm of Action Research there is also an opportunity to carry out the investigation using Soft Systems Methodology (SSM). Soft Systems methodology is an organised way of tackling perceived problematical situations, it organises thinking so that action to bring about improvement can be identified. The complex problematic situations exist in real life and are characterised by being never static and containing multiple interacting perceptions of reality. These situations come about because people hold different assumptions about the world that are frequently unexamined or tested, causing them to see the world in a particular way. These problematical situations also contain people who are trying to act purposefully with the intention of solving the problem. It is these two ingredients that underpin the SSM approach, a process of enquiry which works its way to proposing action to improve the situation through social learning (Checkland & Poulter, 2006).

In SSM if we think of information as differing from data, in that, the former is concerned with interpretation, that is, someone has already started to make sense of something, then the information management becomes the leaning process leading to a solution of the problem (Davis & Ledington, 1991, p2). The parent of SSM was ‘systems engineering’ which looks at ‘how to do something’ when ‘what to do’ has already been defined. This moved experientially from an approach aimed at optimising a system to an approach based upon articulating and enacting a systemic process of learning (Checkland & Scholes, 1990, p 15). The systemic approach here being the opposite to a systematic or methodical approach and meaning system-wide or relating to a group or system as a whole SSM was originally intended for use in complex

situations it involves the use of systemic thinking when looking to resolve real world problems (Checkland, 1981). It is an approach to a problem that takes a broad view and yet tries to take all aspects into account but concentrates on the interactions on the different parts of the problem (Checkland & Scholes, 1990). It accommodates an interpretive perspective and facilitates a multi-view approach where a range of different stakeholders are involved in the process.

In using SSM feasible and desirable solutions are found through the use of conceptual abstract models which are subjected to reality by applying with the intentions of proposing changes for improvement this is outlined in figure 5, (Avison and Wood-Harper, 1990).

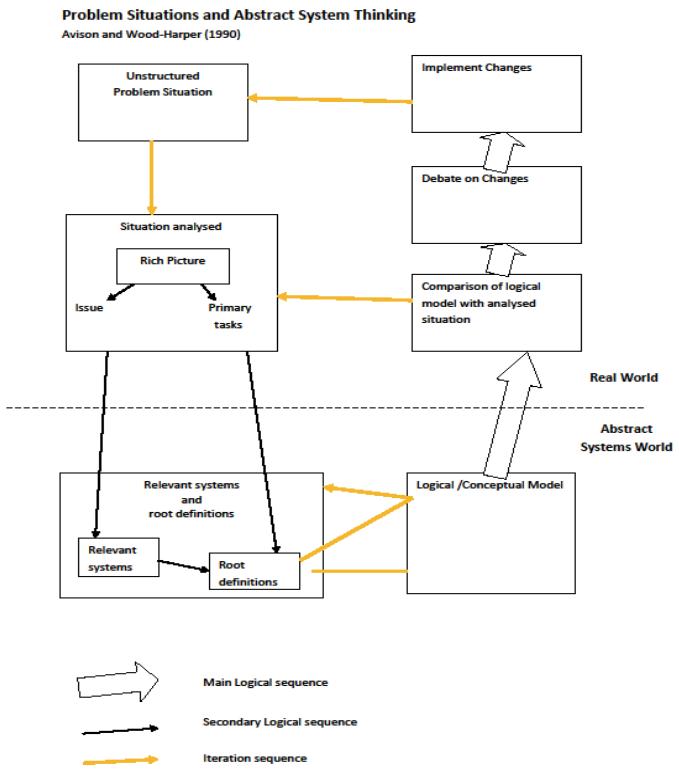


Figure 5. Avison and Harper-Wood (1990) Problem situations and abstract systems thinking

SSM separates real world situations and conceptual situations and the analysis of the problem is made using a ‘rich picture’ which captures a holistic summary through the structural elements and processes and their interrelationships. Problem themes and relevant systems can be extracted from this rich picture and ‘root definitions’ i.e. structured description of a system from its basic source, can be established. SSM uses a criteria referred to by a mnemonic as CATWOE to construct root definitions by identifying the Customers, Actors, Transformation processes, World View, Owners and Environmental constraints. From this a conceptual/logical model can be constructed in order to achieve objectives specified in the root definitions. This model is then compared to the reality so as to deduce the changes needed.

The focus of SSM is on an organised set of principles which guide action on managing real problem situations and it provides a framework which can be used to address quality through the holistic five Es typology (Vigden et al, 1993, p106). The core purpose of SSM is to clarify a transformation process in which ‘some entity – the input - is changed or transformed into some new form of the same entity – the output’ (Checkland and Scholes, 1990, p33). The measures of performance by which the operation of any notional system or transformation would be judged have been identified by Checkland as being, in every case, efficacy, efficiency and effectiveness and in some circumstances elegance and ethicality may also apply. These criteria have become known as the five Es accepted as those quality factors that might be used to judge the success of the adopted transformation. The performance measuring criteria can be summarised as follows:-

Efficacy – did the process produce the required output?
Efficiency – was the transformation carried out using minimum resources?
Effectiveness – were the long term requirements met?
Ethicality – was the transformation acceptable from a value judgement perspective?
Elegance – was the solution over or under engineered, aesthetically pleasing, well designed?
(Barrett, 2008, p17).

SSM is an approach which claims to be able to deal with the changing complexity of real life and it therefore needs to be flexible enough to cope with the fact that every situation involving people is unique. As Checkland states, the human world is one where nothing ever happens twice, not in exactly the same way (Checkland, 1981). The approach needed to be a

methodology containing a set of ongoing principles which can be adapted for use in a way which suits the specific nature of each situation in which it is used (Checkland & Poulter, 2006, p6). SSM can be adopted and adapted for use in any real situation in which people are intent upon taking action to improve their predicament. It is not only a methodology but it is more generally a way of managing any real world purposeful activity in an on-going sense.

A conceptual model constructed around the five Es could address the concepts relevant to the problem situation of this research i.e. which of the techniques of the BPE/POE offer most improvement to the overall asset management process and improved user experience. The five Es criteria could be used to construct an integrative framework which could be used as a tool to measure the success of the compilation of the BPCE and the improvement of the quality of the asset management process.

In order to examine in detail this complex, real world problem an initial study was carried out (phase 1 in table 2) using the derived methodology to establish the actual situation regarding the existing practice and points of view or world Views of the Actors within the field of this research.

3.02 Initial Study - First stage interviews - establishment of the Problematic Situation and World Views

The opinions of all of the parties concerned with the research were sought by gathering data through a series of semi-structured interviews. The analysis of the findings of the interviews are then combined with the findings from the literature review to provide a rich picture from which root definitions can be derived and purposeful activity models developed to enable an accommodation of the multiple perspectives involved. It is envisioned that the data could then be analysed to account for the quality of the proposed interventions. The examination of the overall context and the assessment of the quality of what is proposed will utilise SSM to demonstrate how a complex problem situation has been improved by finding feasible and desirable changes using the rigour of systemic thinking. Table 2 shows how the proposed research was divided into seven stages and how each stage has been completed in terms of the part of the methodology to be deployed, the actual methods used and the action taken.

Table 2; Research Strategy

Phase	Soft Systems Methodology	Method	Action	Research objective
1		Literature Review	Obtain a detailed understanding of the development of POE and BPE techniques and the existing Asset Management process for primary schools.	Objectives 1 and 2
2	Finding out about the problematical situation and	semi structured first stage interviews and analysis of data.	Understand how all of the players perceive the current process and obtain Worldviews.	Objective 3
3	Derive root definitions and build Purposeful Activity Models	Analysis of initial study data	Develop a Root Definition of the problem situation and construct the Purposeful activity models for each group	Objective 3
4	Using Activity Models as a tool to question the model	Analysis of data	a Conceptual model using for further refinement of the BPCE	Objective 4
5	Evaluate the BPCE using the 5 Es criteria	Assessment of the sections of the BPCE using Integrative framework	Assessment of the BPCE content by comparison with existing process using the five Es criteria.	Objective 5
6		Survey and measurement	Carry out BPCEs for designated schools and compile Reports	Objective 5
7		Semi structured second stage Interviews	Gather feedback on proposals for the BPCE content and process from interviews with Head Teachers.	Objective 6
8	Comparison of Problematical situation with findings define the desirable and feasible change to improve the situation	Analysis of the interviews. Critical reflection.	Produce the systemic model of both the BPCE content and the process. Assess the benefits and define the action to be taken	Objective 6 and Aim

The objective of the first phase of this research was to identify the full extent of the progress made in the fields of Post Occupancy Evaluation and Building Performance Evaluation . It also involved an examination of the history and development of Asset Management methods applied to the primary schools of the UK. The information gathered in achieving both these objectives informs the next part of the research by influencing the nature of the questions to be used in the interviews. This was what determined the content of the first stage interviews ie a semi-structured approach was decided upon largely because of the questions arising from the research and not for any particular strategic reason.

The second objective involved carrying out a study to assess the opinions of the distinct groups of stakeholders who are involved with the asset management process i.e. policy influencers i.e. senior management, professional advisors i.e. District Building Surveyors and Building Services Engineers and the building users i.e. Premises Managers (Head Teachers are in all cases deemed to be the Premises Manager, ie holding complete responsibility for the school premises). The questions were designed to generate more detailed discussion and draw out the opinions about how the prescribed process works from each perspective, how well it fulfils the need and what else they think could be done to improve the process. In some cases the questions were quite specific as the subject matter was strongly identified from the literature review for example question five makes specific reference to the need for a sustainability strategy for the school. This was considered to be an important question as environmental issues were found to be present in most of the building performance assessment processes. Also many schools have been involved with Eco-School schemes and they also have a legal requirement (for schools having a gross internal floor area of over 400 m2) to produce a Display Energy Certificate and the results placed in a prominent place for the public to view. There are also other sustainability initiatives that they could have been aware of including funding provision for energy conservation projects eg for low energy lighting, solar panels, etc, all of which are connected with the measurement of existing energy use. Knowledge of many of these schemes was quite sparse amongst the head teachers but when prompted into considering their merits there were frequent positive responses. The arrangement of the questions was an attempt to develop the interview focus from the basic understanding of the building maintenance and improvement works to what more should be provided to improve building management practices and the school building performance.
The interviews were conducted around the the following open and closed questions.

1. What are the principal drivers for carrying out building maintenance and improvement works?

This question attempts to understand how well known the processes were for identifying, prioritising and funding of building maintenance work but also how improvement works could be instigated. It is a very open question and the intention was to use the responses to see if any conclusions could be drawn on the clarity and accuracy of understanding in this area.

2. What are the factors that influence decisions for major improvement works?

This question follows on from question 1 and asks the interviewee to distinguish between minor improvement works perhaps related to planned maintenance work and major projects e.g. increasing the size of the school to accommodate greater numbers on roll or carrying out a major condition improvement. Questions 1 and 2 have the same objective of understanding the interviewees understanding of the application of the property strategy of the local authority.

3. Is there any reference to the Building Condition Survey (BCS) report for the school and if so when is this data used in planned building maintenance?

The literature strongly suggests that the collation of building condition data and its constant updating is of fundamental importance in the asset management process. This question is an attempt to examine how well used the condition data is used in practice.

4. How is reactive maintenance managed and how are escalations to major works evaluated?

The literature draws a line between reactive and planned maintenance and the funding regime of the authority creates a situation where head teachers contribute to a pooled resource for the carrying out of reactive maintenance with a one-off assessed contribution. Planned works on the other hand are funded from the schools own allocated property budget. This question probes the understanding of the process and allows the interviewee the opportunity to comment on how well they think the process works. This is an area of complexity which inevitably lacks clarity which frequently leads to disputes over what constitutes planned and reactive work. The question is also aligned to questions 1, 2 and 3 in that it demonstrates the level of understanding of the local authority property procedures.

5. Is there a sustainability strategy for the school, if yes does this include the school building works how clear is your role within this?

There are multiple questions within this question but the objective is to gain an understanding of the schools outlook towards sustainability issues and to what depth they would consider it appropriate for the school to become involved. There is a considerable focus in the literature upon the efforts of primary schools in achieving high levels of sustainability and the use of environmentally sensitive design. This question is aimed at gaining an understanding of the motivation to carry out assessment of the environmental performance of the school.

6. Are suitability surveys/assessments carried out?

A suitability survey could range from a calculation of the area of floor space per pupil or a complete assessment of how well suited the building is for the purpose to which it is being put including spacial layout, room sizes, teaching intervention spaces, etc. The aim of the question is to prompt opinion on the need for assessing overall suitability of primary schools.

7. Is there any occupier or building user feedback on the building in use?

This question is aimed at identifying what processes exist for people who work in primary schools to feedback their views of their environment and issues that are impacting upon it. In POE the use of occupier feedback surveys have been widely accepted as a means of gaining intimate knowledge of the subject building, how it is performing and how it is used.

8. Is any form of environmental appraisal carried out and what specifically does this assess?

The term environmental performance here refers to the schools overall impact upon the environment but also how this connects to the internal environment maintained within the school. The schools CO_2 emissions give an indication of overall environmental impact but the maintenance of internal temperature has a direct influence on energy use and therefore emissions and so an appraisal of both is considered important.

9. Is there any form of energy survey conducted outside of any statutory requirements for a Display Energy Certificate?

This question examines the knowledge of the interviewees of the energy performance monitoring processes adopted by the authority. It considers the value attached to the reports, the interpretation of their contents and how well they are acted upon. The opinions of the interviewees are sought upon the importance of energy conservation.

10. Are there any procedures for recording internal environmental conditions as part of building performance assessment, i.e., temperature, air quality etc?

In some schools where problems are known to exist some form of monitoring has been carried out to assist with the diagnosis and identification of the remedial work required. This question is aimed at prompting comment on whether such procedures would offer any value if carried out as a matter of routine to identify the air quality for example.

11. Do you think that there is any other information that should be provided to School Premises Managers to assist them with the management of their building in order to deliver a high standard of teaching environment?

This very open question relied upon the interviewee having read and reflected upon their answer well before the interview and enabled them to consider what sort of information would assist premises managers to improve teaching conditions and how. It is a final summing up question concluding the interview and giving the interviewee an opportunity to express any opinion that they may have formed based upon their experience.

The above eleven questions were condensed into five general areas; namely Building Condition and Improvement work, Sustainability, Suitability, Environmental performance and Energy Performance. The responses were grouped into these categories in order to further focus the thematic analysis of the interview content.

3.03 Selection of the schools for the second stage interviews with Head Teachers

In making the decision as to which Actors should be interviewed for the final assessment of the content of the BPCE it was decided to obtain a response from the Head Teachers and there were a number of reasons for this. Firstly, it is the head teachers who are the budget holders and the most likely influencers in having any work carried out for maintenance or minor improvements. In some cases the Board of Governors would need to approve the expenditure but the Head teachers views are normally influential when supported by good reasons. Secondly the desire to ensure that the building performance is assessed and acted upon would be very much in the interest of the Head Teacher as they are responsible for teaching standards and anything that could be done to improve these would be of interest to the Head Teachers. For this reason they were considered to be the most appropriate person to approach with the idea of a BPCE. Finally it has been found to be the case that many head teachers were unaware of the possible impact of teaching in poor air quality or high temperatures or in poor lighting levels. They were also not well informed of the more detailed issues around the subject of building performance e.g. energy usage and environmental issues. Once these issues were explained to them they became more interested in what changes they might be able to make and what savings could result.

In considering how to demonstrate the content and operation of the BPCE to the head teachers it was anticipated that a small number of BPCEs would need to be completed and then the nature and the detail of the assessment processes being proposed could be explained to the head teachers using their own school being the subject of the BPCE. This was considered preferable as it would involve making direct reference to the condition and performance that they could relate to in their schools and the occupier feedback would be more understandable as it would be from the people they know and work with and the data would all be directly relevant to them. An initial selection of schools was made for this purpose and the process of data gathering commenced. After the first two BPCEs were completed and reviewed with their head teachers it became apparent, mainly from discussions with other head teachers at the time of developing the content of the report, that the data being gathered could be presented to any head teachers without it being directly referenced to their own school and they would understand it. Whilst it was clearly more pertinent for head teachers to be questioned about the actual results from their own schools it was the principle of whether to apply a particular technique and the value that it would offer that was the real consideration as well as assessing building performance alongside condition. In almost all cases the absence of a detailed report upon the interviewees school seemed not to affect the interest and curiosity shown from most of the heads as to how the conditions might be affecting their schools. A clear benefit of adopting this stance was that a greater number of Head Teachers could become involved in the research offering their particular views and response to the interview questions.

The first two schools exhibited widely varying characteristics in terms of their age and condition and size and the proposed BPCEs were completed for each school in exactly the same format. The first report was carried out on a Victorian School building with many condition and building performance issues and the second report on a new school built in 2015. The head teachers of each school were interviewed and a copy of the Victorian school report was sent to three other schools in a group of ten with and a copy of the new school report was sent to five others. The Victorian school BPCE was sent to heads of schools which had been built up to 1950 and the modern school report to schools built after 1950. In some cases the heads who were asked to read the report and consider its content requested some further time and some clarification which usually resulted in a number of brief conversations where further explanation of the content was

provided. After a period of between two to four weeks the head teacher was contacted and a time agreed to discuss the content and conduct the interview.

By using the two school BPCEs in this way many of the duplicated activities were removed and this vastly reduced the time allowed for completing the evaluations enabling more time to be spent on other areas of the research. The use of the sample reports and the feedback from a larger group of head teachers enabled the refinement of the report to be carried out and the combined views of ten participants were used to question the perceived real-world situation that has been identified. This was considered to improve reliability than if only three or four opinions had been sought without seriously impacting on the validity of the research.

Once the first two reports were completed and distributed to other school heads it became clear that the presentation of non-specific data could be used to obtain the quality of feedback required. The Head Teachers received a copy of a BPCE usually long before the interviews so that any issues with understanding the reports could be discussed before the interviews took place. In fact almost all of the head teachers failed to read the report in the allocated time and this is an indicator of how daunting the report first appeared. Many of the heads who agreed to be interviewed asked questions during the meeting and entered into a two way discussion about the meaning of some of the data, its use and what it was revealing.

The selection of the schools was also based upon the willingness of the Head Teacher to find the time to read and understand the reports which were approx twelve thousand words in length and show an interest in the possible application of a BPCE for their school. Many of the heads who originally agreed to contribute failed to do so but eventually a sample size of ten was reached. However almost all of the heads that were approached to contribute to the research showed an interest in the content of the BPCE even if they were eventually unable to contribute to the research. The schools selected had a wide variety of sizes and building types and had DEC information showing wide range of energy performance. Their characteristics are recorded in table 11 and some of the buildings particular performance issues and known defects recorded. The interview discussions would frequently touch on these and other known defects known to the head teachers who expressed concerns about the way in which these issues and other improvement plans would be prioritised alongside the performance in the BPCE. It could be said

that the head teachers response to questioning was in some ways still dictated to by the nature of the building that they were connected with and how they related the techniques in the sample reports to known problems or issues in their own schools. For this reason it was considered important to record some of the detail of the schools in table 11. The type of report sent to the school is recorded in the table together with some design features and condition issues plus other general information.

School	School One 1828 - 1890	School Two 2015	School three 1890 with 2010 additions	School four- 1830	school five - 1977	School six - 1908	school seven - 1985	school eight - 1955	school nine - 1960	school ten - 1930
Example BPCE	**school 1**	**school 2**	**school1**	**school1**	**school2**	**school 2**	**school 1**	**school 2**	**school 2**	**school 2**
Design Features	Victorian solid brick envelope walls high classroom ceilings single glazed windows	new school operating for 12 months. high performing envelope and glazing low air tightness	Original dating from 1890s with extension and alterations up to 2010	Early victorian	Cavity wall with timber frame envelope	solid masonry	Cavity wall with glazed curtain walling	solid masonry	Cavity wall shallow pitched roofs with conc tile covering	Recently refurbished internally
Performance issues	summer over heating	summer cool areas wind pressure	High winter temperatures, poor ventilation	poor	heat losses	poor ventilation, summer overheating	summer overheating	not known	poor ventilation	not known
Known defects from Condition Survey	water ingress issues	roof drainage macadam surface failures.	rising damp to internal and external walls	dry rot in ground floor	poor energy consumption	damp ingress, pointing issues poor lighting levels	roof issues poor lighting levels	heating problem	roof issues	frequent roof repairs
Size	180 children 1195m2	220 children 2234m2	161 children 1376m2	197 children 1550m2	46 children 835m2	676 children 3706m2	274 children 1299m2	78 children 1305m2	67 children 1450m2	151 children 3525m2
Low Carbon Technology	none	small PV array rainwater harvesting	none	none	none	none	MVHR	none	Rainwater harvesting	none
DEC rating	E	B	C	D	E	D	C	D	C	D
Setting	Urban	Urban	suburban	Urban	Rural	Urban	semi rural	suburban	suburban	suburban

Table 11: summary of the study schools

3.04 BPCE second stage Interviews

Following the production of the two BPCE Reports and the selection of the schools and Head Teachers for interview it was now necessary to consider the content of the interview. In deciding upon how best to collect the views of the head teachers a list of questions was produced which would be aimed at those areas where the Head Teacher can have the most pronounced impact. The questions also needed to draw out opinion from the head teachers so as to make an assessment of the useful benefit that could be achieved from the BPCE. The questions were designed to assess some of the clear issues that are involved with the BPCE but also to draw out any other opinions which may not have been so apparent by asking open questions. For this reason the qualitative interview was selected as the means of gathering this kind of response. The qualitative interview allow the respondents to reflect on a variety of subjects in a different way than say questionnaires or surveys and for this reason this method was seen as more suitable for the purpose of this part of the research. A qualitative interview can be categorised into two types; a) Exploratory and b) Standardised, (Oppenheim, 1966, p65). In the case of this study the exploratory interview was preferable as only a small number of interviews were to be held and it was necessary for these to look in depth at the research issues. The outcomes from these interviews can be seen as the worldviews of the head teachers. The use of a semi structured interviews were based on a number of both open and closed questions and the participants were all interviewed by the author. The Interview questions were the same for all parties and sought the opinions of the participants regarding the process being followed and the techniques adopted through a general discussion about their usefulness.

The choice of questions to be used was based upon the need to gather as many of the thoughts of the head teachers as possible and to deal with and record their questions. The questions that were asked by the head teachers were indicative of their understanding of the techniques deployed and the meanings from the outcomes. The questions range from general to more specific as follows:-

1. What are your first impressions of the BPCE?

This question is an open question intended to see what the head teacher thought were the most memorable issues dealt with within the report and whether it was easy to read and understand.

2. Do you think that any form of Building Performance Evaluation would be worthwhile and if so what would you say would be the most significant information to be gathered within the evaluation?

This question probes deeper than the first and follows on from the answer to the first question by asking the head to evaluate what was the most useful without inferring that some of the content of the report was not useful at all.

3. Would you see any of this information influencing decisions that you would be involved with for larger planned or improvement works projects?

This question is looking for a response following on from question 2 in that if anything was seen as worthwhile evaluating would it then be used in some way. This question was considered to be a good indicator as to whether the head has understood the report in a practical sense.

4. Do you think that any of this information should be gathered with the condition appraisal and used to inform the planned building maintenance programme?

This question is aimed at prompting a response on how the data should be looked at, either it is used as a matter of routine or simply collected where a problem is known or believed to exist, e.g., poor air quality in classrooms or excessive energy or water use.

5. Do you think that the cost of producing any of this information could be justified even if it did not result in making savings?

This follows the above question in affirming whether the evaluation as a whole should be considered for information purposes.

6. Would you be interested in developing/providing a sustainability strategy for the school using information from this Report?

In suggesting a particular use for the report this question was aimed at prompting the Heads to think of the broader significance of this data.

7. Do you see any merit in formally capturing the opinions of the teaching staff on the performance and suitability of the building for its purpose as a primary school ? Are there any disadvantages in doing this?

This question prompts the Head to think about the effect of using a formal process for gathering occupier input and it openly invited the head to offer their thoughts on how this would need to be managed without artificially building expectations about solutions.

8. Do you think that the occupier survey offers any useful feedback for the asset/ maintenance management process?

This question follows the above by inviting the Head to consider the overall benefit of the exercise of gathering opinion from the teaching and support staff.

9. Is the environmental appraisal of any use in the asset management of the school?

A very direct question about a section of the report where there is data which falls into two categories i.e. the effect the school is having on the environment and the internal environmental conditions of the school. This open question asks the head to align the environmental data to the asset management of the school.

10. Do you think any of the Energy analysis is of any use in the day to day running of the school, if so what do you see as having most benefit?

The Energy Audit is a very large and detailed part of the report but in some ways it has most to offer the school in terms of understanding their energy use and how they can affect it. This question is aimed at drawing a response on the issue of 'day to day' use of the school buildings.

This line of questioning was considered to have developed a good interview focus narrowing the topic into a good width with the subjects woven together whilst keeping the questions relatively distinct from each other (Gillham, 2005, p72). The process of carrying out the interviews was to forward the questions to the heads at least two weeks prior to the meeting so that they had an opportunity to reflect upon their responses. The main benefit of this approach was that the interviewees had time to consider their stance and to question the report, which often led to a certain amount of pre-interview communication and explanation.

3.05 Summary

The nature of the research questions being asked, the subject matter of the research, for example, the collection of quantitative and qualitative data, the collection of stakeholder views through surveys and interviews have all influence the methodology selection. Also the assessment of the processes of asset and building maintenance management and the need to understand how it can be changed and improved for all of its principal stakeholders has impacted upon the choice of methodology. The research is exploratory in nature and is inductive and involving the interpretation of multiple perspectives. The overall objective of this research is to examine existing practical processes and to consider how these may be combined to better serve a particular type of buildings. The problem clearly exists independently in a real world situation where the truth is created by meanings and experiences in a given context. This strongly suggests that the research philosophy of this study is one of Pragmatism and founded within an emic, interpretivist epistemology. An emic epistemology is one where the research is being carried out from a position within the problem situation which is particularly relevant in the case of this research where the researcher is embedded in the activities being considered.

Pragmatism argues that the most important determining factor in selecting the research philosophy is found in asking the question ‘is one approach ‘better’ than the other for answering particular questions’. Moreover, if the research question does not suggest unambiguously that either a positivist or interpretivist philosophy is adopted this confirms the pragmatist’s view that it is perfectly possible to work with both philosophies. The interpretivist epistemological stance of the research is symbolic interactionism as there is a continual process of interpreting the social world around what we interpret in the actions of others with whom we interact. This interpretation leads to adjustment of our own meanings and actions. The interpretivist would argue that generalisability is not of crucial importance in an ever changing world, but there is a question about the generalisability of research that is based upon a particular set of circumstances and individuals.

The ontological position has been identified as relating to a problematical situation which exists independently in a real world situation where the truth is created by meanings and experiences in a particular context. The Ontological position is therefore one of subjectivism which holds that social phenomena are created from the perceptions and consequent actions of those social actors concerned with their particular existence. The necessity to study the details of the situation to

understand the reality or perhaps the reality working behind them is often associated with the term 'constructionism' (Remenyi et al, 1998, p35). This follows the interpretivist position that it is necessary to explore the subjective meanings motivating the actions of social actors in order for the researcher to be able to understand these actions. Social constructionism views reality as being socially constructed. Social actors, such as the head teachers of primary schools may place many different interpretations on the situations in which they find themselves. So individual heads will perceive different situations in varying ways as a consequence of their own view of the world. These different interpretations are likely to affect their actions and the nature of their social interaction with others.

The use of Soft Systems Methodology has been identified as the most appropriate means of carrying out the initial part of the research as it offers a way of looking at the combined worldviews of all of the owners of the issue and all of the inputs to the process. It also identifies a set of principles which could be investigated with a view to making them a part of a building performance evaluation process. The real-life nature of the issues being examined throughout this research and the need for an exploratory and flexible approach strongly points towards the use of SSM.

The stage one interviews have been structured to draw out the present problematical situation and the actual processes that are taking place. These questions have been compiled with the benefit of the author having worked within this environment for a period of five years and during this time gaining an understanding of the issues that are present. The questions attempt to invite comments on the fundamental processes such as question one; 'what are the principal drivers for carrying out building maintenance and improvement work?' Inviting the interviewee to express their understanding thereby enabling a picture to be built up of the extent of common understanding at a basic level. This provides an indication to what extent people within the process are acting purposely towards a common goal.

Other questions are put to the interviewee regarding activities that are not carried out or only to a limited extent these prompt the interviewee to consider whether these activities, such as suitability assessments or environmental appraisals, should be carried out and what benefit they might provide. These questions led to a discussion for some subjects in which the interviewee reflected upon their answer and sought some input from the interviewer. The response of the

interviewer was only explanatory and the final input must be that of the interviewee and as closely reflecting their actual words as possible.

All of the questions are structured within five general areas; building condition and improvement work, sustainability, suitability, environmental performance and energy performance and the responses are grouped in these areas in the thematic analysis of the interview content. The types of interviewee were also grouped into three areas ie head teachers, building surveyors and engineers and senior management the results of the analysis then feed the construction of the purposeful activity models for each group.

The production of two reports for two very different types of school building provides the opportunity to gain feedback from a larger group. The original idea was to use the report to obtain feedback only from the head teacher of the subject school and to complete four or five evaluations. The selection of a group of ten schools gave the opportunity for a wider range of views to be obtained on the content of the report although this would involve some further explanation of the technical content of the report.

The second stage interviews of head teachers on the content of the BPCE have been compiled of open and closed questions which are similar to the stage one questions in that they are devised to obtain responses which identify needs and also open discussion on the issues involved. The questions are direct so as to avoid any misunderstanding whilst also looking for a practical and useful application from the report content. In may cases the questions prompt the head to consider the effect and cost of using a formal method to capture data on a routine basis or whether to investigate particular issues as they arise.

4.0 Initial Study Interview Analysis

The participants in this study included 3 senior managers, 3 surveyors 1 engineer and 6 head teachers. The group comprised 9 men and 4 women, all of the women being Head Teachers. The combined years of experience of the surveyors and engineers was 61 ranging from 3 to 25 years, giving an average experience of over 15 years. The senior managers combined years of experience at their current level was 40 giving them an average experience of over 13 years and the head teachers possessed a combined total of 56 years giving an average of over 9 years. One of the head Teachers had only 1 year experience with the authority but it was considered that this was not likely to have a negative effect. The knowledge of this member of staff was considered likely to be good having been recently involved in an induction process and placed at a school with numerous building issues requiring him to quickly gain an understanding of the process and it was decided to include his interview as part of the data.

The context for this initial study was a group of primary schools selected from one area of a large northern county of England. The schools were all located in or around a large town of the region where there are a total of approximately 100 schools whose buildings are directly managed by the local authority. The total number of primary schools across the county which the local authority has a direct involvement with is a little over 400.

Having identified the third objective of this research as gathering the views of Premises Managers, their professional advisors and senior managers the next stage of the research involved identifying suitable and willing candidates for interview. The main reason for selecting an individual was that they were key players or Actors in the scenario of the asset management process. The type of involvement that was required to produce the rich picture was identified as containing senior managers, technical staff and head teachers and so contributions form each level were sought. These classifications are comfortably positioned within the soft systems methodology adopted as the Actors in a problematic situation which is in need of transformation to a more desirable outcome. The analysis of the interviews was thematic in nature and involved collating the responses from each of the three groups. The questioning structure of the interviews engendered a discussion about this real world situation and drew out different worldviews of the situation. The intention being to compare these worldviews and identify improvements which could accommodate more than one worldview. From these worldviews three purposeful activity

models will be generated each yielding further questions of the problematic situation which will guide the production of a conceptual model. The model will represent a group of people trying to act purposefully in a complex problematical situation and will show the desirable and feasible improvements. However, these improvements will not necessarily be an absolute solution to the problematic situation for all, they will represent a worldview that all parties could live with.

The first part of this process involves a thematic analysis of the interviews for each group and the use of Qualitative interviews was considered to be an appropriate means of achieving this. Qualitative interviews allow the respondents to reflect and reason on a variety of subjects in a different way than say questionnaires or surveys and for this reason this method was selected as the instrument for the purpose of this study. A qualitative interview is not an ordinary conversation and can be categorised into two kinds; a) Exploratory, depth or free-style and b) Standardised, (Oppenheim, 1966, p65). In the case of this study the exploratory interview was preferable as only a small number of interviews were to be held and it was necessary for these to look in depth at the problematic issues associated with the research. The qualitative interview offered the flexibility to explore the requirements of the Head Teachers and what they perceive to be the priorities for their teaching needs whilst at the same time investigate the technical opinions of the professional advisers and the strategic views of senior management. The nature of the practice gap identified in the literature review between good practice guidelines and actual practice could also be looked at from a number of perspectives.

The interviews were based on a number of both open and closed questions and the participants were all interviewed by the author. The Interview questions were designed so that they could be the same for all parties and to bring out the opinions of the participants regarding the processes being followed. This eventually came about, in most cases, through a general discussion about the merits and demerits of the existing processes. It also sought their views on such matters as sustainability, suitability, environmental performance and energy performance as these subjects were identified as being important from the literature on building performance. The questions also aimed to gather data about the opinions of the participants of the service actually delivered and some questions about particular activities that might be added to the process to improve it. This latter category involved suggestions being made to the interviewees so as to prompt their thinking as to what might be included in a BPCE and in order for them to have time to reflect on

this the research summary and the questions were forwarded to them in advance of the interview. Each interview was digitally recorded and then transcribed so as to enable the analysis to take place using a pattern coding strategy (Miles and Huberman, 1994).

The results for the semi-structured interviews can be summarised in the three distinct groups of interviewees and the five categories of the questions as follows:-

4.1.1 Head Teachers (Premises Managers)

1. Building Maintenance and improvement work

The coding exercise for the first part of this study is represented in Table 1A of Appendix I in which the first group of questions were amalgamated. This was carried out in an attempt to understand what were the key drivers for carrying out all maintenance and improvement work, to what extent the Building Condition Survey (BCS) was relied upon and how maintenance works could escalate to major work. The themes which emerged from the process demonstrated that the BCS is instrumental in prioritising building and H&S works and is used for financial planning. It also showed that the attainment of a good environment for the well-being of the school occupants is also a major factor. To a lesser extent the data showed that Premises Managers seek professional advice to achieve value.

Whilst the findings from the coding exercise were strongly suggesting that the BCS was a useful tool for prioritising important work and financial planning most of the head teachers admitted in the interviews as to *'not having very much time to look at it'* and making vague statements like '*Yes I have seen it and it gives a number for the severity of the work'* clearly indicating that they do in fact refer to it very rarely. They also admitted that the fine detail of the report was never very much use such as proposed timescales for redecoration or the replacement of floor coverings as this would be dealt with when the school decided that wear levels were visually unacceptable or a potential H&S issue such as a tripping hazard.

The importance of the twice yearly formal property review meetings with the District Building Surveyor was also emphasised as being much more significant than reference to the BCS, *'I*

couldn't say where to find it but I have looked at it, I think it has been updated in the last 3 yrs and I think in our initial meetings we have looked at it to prioritise works'. This meeting allows for a brisk review of the BCS to simply identify if there is any H&S or statutory compliance issues and any major expenditure planned as a result of serious building defects or components failures. The priorities identified by the head teachers are then considered and included, sometimes as a higher priority than the non-statutory planned maintenance work, in compiling a School Maintenance Improvement Plan (SMIP). The statutory requirements contained in this schedule include such things as testing of the electrical installation, legionella risk assessment, asbestos inspections , etc. The document is then reviewed at future meetings both formal and informal and is popular with head teachers as it is a clear and simple way of identifying the required expenditure for the short term. This supports the finding that the they want to receive professional advice for technical support and to achieve value amongst other things.

2. Sustainability

The subject of sustainability was strongly supported by the head teachers and they expressed a strong intent to make their schools more environmentally friendly. It was viewed in this way by almost all of the head teachers. However none of the schools had a formal written strategy and five out of the six heads questioned thought that it would be a very good idea to have one and some thought that it would be a good idea to share it with the children and use it as a teaching aid *'sustainability has real tangible learning benefits not just in the sense of its importance but that they are involved in something real, and the more you can give children something to look at that is real they will engage with it that much better'*. The only head teacher who made the assertion that a *'sustainability strategy would be a waste of time'* did so on the basis that there were so many other property related problems with her school that it was *'just not on the agenda'.* In principle she agreed with the idea of promoting sustainability within the school and at her school there were several waste management initiatives but nothing that would involve an investment of school funds.

3. Suitability and occupier feedback

Suitability surveys were once carried out by the local authority on a routine basis to try to capture the extent to which the schools were fit for purpose as part of the asset management process although this practice ceased many years ago. The head teachers were generally very

interested in this subject area '*Conditions for learning are extremely important and I would value an input on this'*. There was a widespread acknowledgement that teaching standards have risen since the 1988 Educational Reform Act as although greater budgetary responsibility brought greater responsibility it also allowed more flexibility to spend school budgets on improved teaching methods. The observation that standards had moved on and left some school buildings increasingly obsolete and unable to accommodate the new pedagogy were frequent *'this school it was built 120 years ago and there are parts of it that are not really usable as a modern primary school and so we make the best we can with the building'.* Amongst all of the head teachers was a strong desire to recognise the degree of inappropriateness of the building in which they were teaching as a factor working against the achievement of good academic results.

The use of a mechanism to capture staff contentment with their working environment was also viewed very positively *' I would really like to look at a building user survey format for this school'* and '*that sounds quite useful and I would be interested in that'.* It was viewed as a formal means of capturing feedback for improving the school environment in addition to what was usually captured at staff meetings and informal staffroom discussions. There was some negativity with regard to asking people to offer opinions about what should be done to improve the school and then failing to act on anything due to lack of funds. Some heads felt that this could be a major disadvantage possibly leading to a lowering of staff moral.

4. Environmental assessment

Environmental assessments of classrooms had taken place at one of the schools in order to measure the perceived poor air quality and high temperatures in classrooms following the removal of all opening windows from within the school classrooms. This was a major project that had not produced the desired effect with the installation of mechanical ventilation. All other schools had never undertaken any form of measurement of the environmental conditions in their schools. A brief discussion was held about what their current means of ventilating classrooms were and the DfE recommended levels of CO_2 concentrations for teaching as contained in Building Bulletin 101 (DfE, 2006). The consequence of teaching in high CO_2 concentration environments was also discussed in the light of some recent research. The head teachers expressed a lot of interest, '*absolutely, yes it would all be useful because again you come down to the fundamental areas of physical learning in terms of peoples' needs and which has a*

pedagogical benefit' but also some trepidation about what they might discover *'How could I respond to it if it was bad?'* and there was a general concern expressed about their schools and suggested that they would like to know more *'yes it would be interesting to know what the teaching conditions are in the school and also for lighting levels.'* Heating, lighting and humidity and CO_2 levels expressing the air quality in teaching areas was generally considered to be of a high importance and worth measuring so see what effect they were actually having on teaching.

There was some interest from the head teachers of schools with large grounds in that they felt that a broader environmental assessment of the site with an ecological emphasis would also be worthwhile *'for me it ticks a lot of positive boxes and at the moment our experience of it is trying to make use of the school grounds for ecological purposes etc'*.

5. Energy assessments

All of the schools in the study have a Display Energy Certificate produced on an annual basis and these were generally viewed with mixed feelings. Whilst there was a common belief that they were a good thing there was also some doubt about their usefulness *'So the surveys are not much value unless they come with real recommendations and detailed proposals for investment, payback, etc'* There were some schools who had considered the installation of solar panels to their south facing pitched roofs for both hot water and electricity generation but none had been convinced that they were a worthwhile investment and felt they were being put under pressure by sales people rather than receiving professional advice as to their best course of action. *'I have met companies about solar panels and things like that but when we have looked into the cost and the payback period we have not had the capital to invest over this sort of time. How cost effective it is really?'* few head teachers acknowledged the existence of any form of energy report produced by the authority and yet there have been great efforts to install smart metering devices and publish up to date monthly gas, electricity and water consumption figures for the schools.

The last question of the interview asks if there is any other information that the head teachers would like to assist them in the management of their buildings. There were some general comments about the production of better quality finance reports and the need for funding that was specific to the need of the school and not just based upon numbers on roll, but, the overall

response requested greater support on internal environmental issues, suitability and gathering user feedback, and advice on sustainability and in particular reducing energy use.

4.1.2 Surveyors and Building Services Engineers

1. Building Maintenance and improvement work

The surveying and engineering staff were very unified in their opinions on the drivers and influences being primarily health and safety issues relating to building condition followed by statutory compliance and then building condition issues from the BCS. They also referred to the problems with financial restriction and the increasing deterioration of the older existing stock producing planned preventative maintenance issues of increasing size and cost. Finally the reactive repairs and the need to respond within reasonable timescales and '*to keep the building functional'* as one surveyor put it.

The experience of the head teachers in relying upon their technical support from Surveyors and engineers to identify major or compliance works was endorsed, with all surveyors claiming to use the BCS in the same way just considering the major works and even, in some cases, re-evaluating the findings of the survey for items included in the major works capital programme. In focusing on the shorter term the SMIP disregards a considerable amount of the content of the BCS with one surveyor describing the smaller items as being *'self evident and driven by the teaching staff rather than the condition report'* and *'I think that they* [the heads] *will prioritise what they want more than condition'.* This latter comment was indicative of a common theme amongst the surveyors that the process of delegation of funds to the head teachers has resulted in a diversion of building maintenance funding to other things; *'we might have situations where we believe that there is something that is an immediate H&S issue where we advise them that this is the case and suggest its placed on the SMIP but it is not unknown for the Head to decide that they have more pressing priorities in terms of improving the internal school environment and facilities and they divert the spend into those areas'.*

The results of the analysis of the interviews consolidated the responses from the head teachers in recognising the importance of the property review meetings and the need for a clear understanding of the importance to complete some work and to be able to consider putting off other works to meet other pressing priorities for educationally driven issues.

2. Sustainability

There were some mixed views from the surveyors on this subject, some surveyors felt that much more was required *'we could deliver much better advice on Energy Management and advising schools on sustainable construction'* whilst another surveyor made the point; *' I think that most of our work involves repairing like-for-like there are issues of sustainability that we would get involved with for things like boiler replacements with our engineers but mainly just complying with building regulations.'* And the engineers point of view was expressed with the statement; *'No, all we do is comply with building regulations, I think that the Energy Team should offer advice on sustainability issues'*.

The head teachers expressed a desire to produce some form of sustainability strategy for their schools and this is mirrored, to a degree, in the sentiment that some more focus on sustainability is needed. However the technical staff recognised that more training would be required and a common policy promoted *'but this could obviously not be addressed without clearer guidance'*.

3. Suitability and occupier feedback

The surveyors held a much less enthusiastic view than that held by the head teachers regarding the need for suitability surveys as this seemed to be remote from their current practices *'I have felt very detached from their* [asset management team] *work and if I have identified any suitability issues the interaction has been generally negative'*. But there was also a degree of acceptance that this is also an area which is fundamentally inseparable from the work carried out by the building surveyors; *'I think Building Surveyors should be more involved in the suitability process'*. There was once a considerable effort made by the authority to capture building suitability and to use this data when assessing the priority for replacing old schools. However this exercise seems to have suffered for a lack of funding and also funding for replacing old schools. There is also a question as to whether it serves any useful purpose to identify and record

a school as being so unsuitable as having its educational outcomes affected when there is a very limited chance of being able to provide a new school.

The use of occupier feedback reports was also frowned upon by many of the surveyors as being *'a bit time consuming and sometimes the quality can be a bit questionable'.* There was some recognition that many of the building defects that building surveyors and engineers are called to look at are generated by an occupiers request but there was a general consensus that inviting comments would always produce issues with buildings that were previously unnoticed.

4. Environmental assessment

The idea of carrying out internal environmental appraisals raised a number of interesting responses from the surveying and engineering staff in that although they believed that there was a fairly widespread problem with air quality in classrooms, they believed that the Energy Team were rightly responsible for issues of this nature; *' I do not think that teachers are fully aware of the environmental effect on teaching and if they were I am sure they would want to find out how they could improve this.'* This statement contrasts with the experiences found with the head teachers as this was exactly their response when they were advised of the effects of teaching in high CO_2 environments. There was a general agreement that the surveyors and the engineers had a responsibility to adopt practices that would reduce environmental impact in situations where contractors were being managed on site and where components or appliances were being specified. The technical staff also strongly felt that the overall environmental performance of the school was again the domain of the Energy Team and that any appraisal beyond the DEC would be questionable without reference to a specifically identified problem.

5. Energy assessment

The authority's Energy Team carry out an appraisal of energy use and produce the Display Energy Certificates for the schools, smart metering enables the real-time monitoring of electricity use so that individual users can be identified as being problem sites. The impact of building surveying work on the energy performance of a school building can be considerable and there are some obvious areas where the process could be improved *'I believe we do not have a joined up approach for delivering basic building maintenance and alteration and improvement and sustainability or energy assessment and improvement.'* There was a general feeling amongst the surveyors that there was a benefit in identifying where and how gas and electrical energy was used in order to find areas where excessive energy use was taking place. This was however also

deemed to be the responsibility of the energy team and it was the view of the surveyors that they only really become involved with energy use when called upon to carry out building improvements such as the renewal of windows or new boiler installations etc. In these cases they believed that it was their clear responsibility was to comply with Building Regulations and in most cases this involved a like-for-like replacement or repair; *'I think that most of our work involves repairing like-for-like'*.

The building surveyor's position on what more could be provided was largely unanimous on the view that a lot of information and support is already offered and this is so much that head teachers struggle to utilise it all. However there were some views to the contrary; '*The CO_2 measurements that have been carried out is a must to improve the performance of the children and their learning environment'* and *'it is important to achieve better standards so we should expect be more involved with looking at the air quality issues.'*

4.1.3 Senior management

1. Building Maintenance and Improvement work

The view of the senior managers interviewed were clearly aligned on the drivers for Building Maintenance and improvement works i.e., building condition and Statutory compliance at a corporate level and at a local level; *' the surveyor to extract info from the BCS to incorporate in the SMIP. The head teachers will have their own priorities promoting teaching practices and the overall appearance of the school'* a discussion would follow in which any important asset protection or H&S issues would be stressed and the head teacher urged to set aside funding for this purpose. '*The personal interface between the district surveyor, the head teacher and the governors is the best way of making this work'* The BCS is viewed in greater esteem by senior management and they have clearly been supportive to the idea of committing funds to keeping the surveys as up to date as possible. However there is a recognition that they surveys capture more information than is required; ' *we are at the point where we need to stick to wind and weather-tight and statutory compliance, legionella works etc what we have found is that we collect too much detail and we are not even able to complete all of the priority one works for the year'*.

2. Sustainability

From the interviews with the head teachers and surveyors it is clear that the overall sustainability strategy for the LA is not being picked up by the Property Group; *'What there is in fact is a complete disconnect now between Building Maintenance and any sustainability policy, all planned works are primarily based upon condition and building regulations*.' The reason for this seems to be due in a large part to the issue of funding and financial pressures to do more with less. *'I am not convinced that the County strategy percolated down to the property group I mean it does cascade when you are producing a scheme and specifying materials like hardwoods etc we specify that a sustainable source is used. There are no requirements to go beyond building regulations but funding is tight and there is more need to keep the school open'.* There is an obvious pressure upon the property regime when the funding does not enable the year one work to be completed from the BCS but there is little evidence to see what investigation has taken place to understand what could be done and at what cost.

3. Suitability and occupier feedback

No suitability surveys have been carried out since 2001 when they were last being updated. *'Suitability is now linked to sufficiency but building surveying works are totally governed upon condition*.' The very basic sufficiency surveys are carried out only when net capacity issues arise and school premises are checked for their safety in being able to support the necessary increased numbers of children. Building user feedback is something that is only rarely captured by the authority as part of post occupancy evaluations of new buildings and it was never envisaged that any account could be taken of such data in considering building improvement work for the existing estate.

4. Environmental assessment

The senior management view of the need for internal classroom environmental assessments was similar to that of the head teachers and the surveyors '*offering a classroom monitoring capability could be something of real value to our head teachers in their efforts to improve standards'* There is always of course the risk of the solution being out of the range for the school budget. There is one way in which the research on CO_2 levels has affected new primary school designs in that '*we now install CO_2 monitors and a traffic light warning system into our new classrooms'.* No formal assessment process exists for the overall environmental impact of schools they may be required to have the DEC carried out but beyond this there is no

requirement although the schools can become involved in various schemes; *'the eco-schools scheme is very popular and offers a means of involving the children in the assessments and monitoring performance'.*

5. Energy assessment

The views on the introduction of renewable forms of energy was met with mixed opinions by senior management in that in one interview a discussion was held which led the interviewee that '*it was simply just not possible to think of this authority building schools to Passivhaus standard without there being a major structural change in procedures and significant additional funding being made available*'. The rush towards the introduction of new technology has slowed following a number of failed installations involving biomass boilers and Ground and Air source heat pumps. Although it was recorded that *'More is worth doing to address the sustainability issues and meeting govt targets through a robust energy policy'* and there is still the will to pursue low carbon technology *'a policy is being developed for the recommended specification of boilers to meet the LAs sustainability strategy in the future'.*

In all cases the senior management felt that the head teachers were provided with *'adequate and sufficient'* information to run their schools and that if they wanted anything further they could request it and fund it from their school budgets. The issue about what should be provided in support of head teachers is one which is '*under continuous review and all new ideas and suggestions are considered in terms of their benefit and value'.*

The content of these interviews and the findings generated from their analysis produced various themes about the nature of the problematic situation that were beyond what was originally envisaged but which added a richness to the overall perception of the problematic situation. It was originally thought that the problem with the prevailing asset management techniques being deployed was that they paid no regard to the building performance. It therefore followed that without any effort to examine the building performance then any likely impact from the existing method could not intentionally influence it. The interviews did bring out the need to measure the building performance and to respond to it with corrective action alongside the existing condition driven regime.

It was also found that there are clear deficiencies with the current system as perceived by the head teachers, who are actually the budget holders and the client in this process. They felt strongly about the provision of services that have been cut, ie the suitability surveys and the lack of explanation as to the content of the Building Condition Survey. This prompted a good response for the occupier feedback and the internal environmental appraisal which was perceived as something that would support the occupiers comments.

The fourth objective of this research identified the need to construct a conceptual model which would involve compiling a proposed list of techniques that could have the potential to add value to the asset management process for primary schools. This has been achieved with reference to the literature and from the initial interviews and the discussions that took place. The discussions with the Surveyors and Engineers were based upon the same questions as were raised with the head teachers but enquiring about the individual's experiences or what they perceived to be delivered by the existing processes in these areas. They were also asked about their opinion of the particular subjects and whether they considered them to be worthwhile or not. The findings from the interviews and the literature review are then considered in compiling the list and a sample of the results are contained in Appendix I and the list produced from the feedback is shown in table 3.

In the study there were many common themes across the three different groups and almost all of the people interviewed believed that old processes devoted to serving old values will change and look towards a greater focus upon improved performance of primary school buildings. The first four questions of the interviews focused on the subject of building maintenance and improvement works and how the building condition survey is used to capture the need and priority. The feedback endorsed the method for the capturing the major, high priority works and in achieving this making a detailed examination of the building envelope, building services and all internal areas. The minor works captured in the BCS, especially those of a non-urgent, but non the less very visual nature, appear to be of very little use in view of the way the process is aligned to other methods of capturing and deciding upon whether to carry out the works in conjunction with the head teacher. The subjective process of assessing the need to carry out works to finishes and coverings for example is also often prevented by a severe lack of funding. An obvious link with the findings of the literature review is that this survey time could be better

disposed to an examination of aspects of the building use that may more meaningfully impact upon performance. This activity has been described as a 'forensic walk-through' (Bordass et al, 2001) and the opportunity to bring together the expertise of the building surveyor and the building services engineer to focus upon what might be called a ‘building performance survey’ could be viewed as a logical step forward.

Making the link between the building condition survey and the building performance evaluation could provide a further opportunity to collect energy data in terms of the school energy use figures and undertake a detailed investigation to offer an explanation of the figures in terms of the performance of such things as the building envelope, heating system, energy using appliances etc. This could offer the school an insight as to how to make an impact on their energy consumption whilst also being provided with a number of improved sustainability options and associated costs.

The monitoring of internal classroom environments could be carried out with the use of data logging devices placed in each classroom so as to provide a record of temperature, relative humidity and CO_2 levels. However this activity is unlikely to provide good results during the warmer period of the teaching year and it would be favourable for this to be carried out during the winter periods when the use of opening windows for natural ventilation is less likely to occur and CO_2 levels are at their highest. There are a great many other things that could be measured as part of an internal environmental assessment including air tightness, light intensity, noise levels, pollutants, allergens and pathogens, volatile organic compounds (VOC) of various compositions and forms (e.g. formaldehyde) and their overall combination expressed as total volatile organic compounds (TVOC), Carbon monoxide gas, electromagnetic fields and radiation (including radon), etc (Meir et al, 2009). The need to refine this list and possible insights as to why and when to do so is the domain of future research.

Overall environmental impact surveys which consider all of the schools activities in such detail as how people travel to and from school, how waste materials are dealt with, how much water is used, the ecological merit of the site, etc there are a number of standard environmental report cards which are used as checklists. Whilst this is an activity that most head teachers interviewed said that they would like to support it they were doubtful of its cost benefit.

The subject of building suitability so warmly welcomed by the head teachers and yet eagerly abandoned by the authority fifteen years ago, on finance grounds, is difficult to justify as a high priority technique for the BPCE. The question of assessing how well an occupiers activity fits into an existing building has been shown to be able to be dealt with as an objective exercise (Hartkoff, 1986, Markus et al, 1971) and it would seem logical for Authorities to want to know which of their buildings perform badly and which perform well in this respect. The inclusion of a form of user feedback is a much less onerous task and can be a vital component in understanding some of the more subtle problems with a building and has been very successfully deployed in a great many POEs (Bordass and Leaman, 2005).

The prioritised list of techniques shown in table 3 has been developed from the literature, the outcomes from the interviews and an assessment of the current practice. The list forms the basis for the development of an integrative framework to conceptualise the actions required to deliver all possible outcomes and options. This will enable all of the goals and aims of the parties to be taken into account and a maximum value scenario to be created through a collaborative process.

	Exercise	**Applicable Technique**	**Comments**
1	Building Condition survey with Surveyor and M&E Engineer	Building performance survey	A building condition survey or building maintenance inspection which captures condition of the structure, fabric, finishes and components can also capture detailed assessment of features of building use that will impact upon energy use.
2	Building Condition survey with Surveyor and M&E Engineer	Internal Environmental appraisal	Temperature, CO_2, Relative Humidity, natural and artificial lighting levels . An exercise of measurement and data gathering to evaluate actual delivered performance. Data logging and spot measurements over a period of weeks
3	Feedback from users	Building User Survey	An exercise in obtaining feedback from building users on several aspects of building performance including thermal, aural and visual comfort, air movement fresh air availability ability to control internal environmental conditions completed by teaching staff. Further investigation following the identification of issues raised by staff in the survey.
4	Feedback from users	Building user Survey - Suitability assessment	An exercise to identify and record the design suitability of the school for modern teaching methods including layout, privacy, flexibility, storage in BUS format completed by teaching staff

5	Desktop Energy review	Energy use survey	Electricity, gas and oil consumption calculated and compared with data for other similar premises with recommendations for improvements and adjustment as required.
6	The School Maintenance Improvement Plan	conclusions from building condition survey and energy survey	Meeting to discuss recommendations from the building condition survey and the energy use data to discuss recommendations for sustainable improvements and the development of a School Maintenance Improvement Plan. Consideration to the possibility for the provision of robust renewable energy solutions.
7	Sustainable buildings policy Review	production of the school building Sustainability strategy	A culmination of all of the performance aspects of the BPE to produce a site specific strategy that is aligned to any higher level strategy or to an eco-schools programme . Consultation between building surveyor, M&E Engineer, Premises Manager and any other required consultant with BPE data to provide an overarching strategy.

Table 3: A non-exhaustive schedule of BPE techniques and their proposed use for primary schools

The individuals who kindly made up the sample in this study came together by a random selection from a group of colleagues based upon their availability and their willingness to contribute to the research. The head teachers were all from a single district and none of their schools were connected in any way to the surveyors interviewed. There are over 400 head teachers in the County and the region of this study contained 23 from which there were 6 contributions i.e. 26%. The sample is therefore 1.5% of the county's head teachers and so the external validity of the research could be said to be low. However the range of experiences of the heads, the size of their schools and the ages of their school buildings were reasonably closely reflected in the area from which they were taken i.e. 23 schools see table 4. The degree to which the area matches the entire county would appear to be similar although no data was available to confirm this with any accuracy and a judgment was made from the discussions with the surveyors and senior managers who suggested that the proportions across the county are an approximate match.

Age	Schools in the Area	Schools in the sample
Pre 1920	34%	50%
1920 - 1960	22%	17%
1960 - 1980	22%	17%
1980 - 2017	22%	16%

Table 4: comparison of ages of schools in the sample with schools in the immediate area

The size of the sample of senior managers was 50% of those from the building maintenance and asset management team and this included a principal surveyor a head of the department and his line manager the Deputy Property Director which represents a good spread of knowledge and influence. The building surveyors and engineers represented 22% of the team with a range of experiences from 3-25 years in the role.

A larger sample of head teachers would have been an improvement to this data and the involvement of more district surveyors and engineers. It may also have been a benefit if the selection of head teachers was further spread and not just from one region of one County. The quality of the data would also have been more representative if the school sizes and ages were a closer reflection of all of the primary schools in the UK. However the overall effect of these issues are very minimal considering that the main concern is to evaluate the importance of assessing the performance of any building in unison with it's building condition.

One of the findings from the literature is that the Post Occupancy Evaluation has no real accepted definition or approved content and neither does the Building Performance Evaluation. They have both become used in many different guises with a wide range of applications and perspectives as to what should be measured, to what depth and how. The deciding factors on what a POE or BPE will comprise would appear to largely depend upon the requirements of the person instructing the evaluation, the nature and use of the building and the nature of the problems that exist within it. The focus of any particular part of the evaluation will also be determined by these factors together with the depth of the investigation carried out within each particular technique.

It was also found that an imbalance exists within the existing asset management process with regard to a three stage approach; initially with the Building Condition Survey highlighting the need for very high maintenance expenditure over a long time period. The review meetings between the head teacher and the building surveyor then condenses the condition information down and the SMIP is produced which actually becomes a more useful ‘dashboard’ type of document. A very wasteful part of this process is the time spent capturing a considerable amount of minor work items such as cyclical redecoration or small repairs which could be seen as house-

keeping items. If any of this sort of work is considered important they will be brought to the attention of the District surveyor by the head teacher.

One of the most significant outcomes from the initial study was the response of the head teachers, surveyors and senior managers to the research showing the effect of teaching in classrooms with high CO_2 concentrations. Their appreciation of the importance of identifying poor environmental conditions in teaching areas was unanimous and their interest in considering how to improve the situation took on an elevated priority. This was something that all head teachers expressed an interested in, even those who had no interest in sustainability or energy assessments. It was also considered to be an important issue to resolve both by the surveyors and the senior management and a number of schools across the county have been monitored where poor air quality was suspected. In some cases the measurement of the CO_2 concentrations over a period of time during the winter term has resulted in remedial works being carried out by the schools, e.g. the installation of mechanical ventilation with heat recovery.

5.0 Systems Thinking - Construction of Purposeful Activity Models

Systems ideas concern interaction between parts which make up a 'whole' and the core systems idea is that of an adaptive whole which can survive through time by adapting to changes in its environment. An important feature of something described as a system is that it must have some properties as a whole that it does not possess as the individual parts, referred to a 'emergent properties' (Checkland & Poulter, 2006, pp 7-8).

SSM is an organised way of tackling perceived problematical situations and identifying possible methods for making improvements. The real world problematic complexity of situations involving people often contains multiple perspectives laden with taken-as-given assumptions about the world and these situations always contain people who are trying to act purposefully with intention (Checkland & Poulter, 2006). These two ingredients ie conflicting worldviews and purposeful activity lead the way to tackling the problematic situation and they underpin the SSM approach. In Chapter 4 a study of the different worldviews of the complex process of the asset management of primary schools was carried out using the semi structured interviews of the three groups of Actors within the existing process; the head teachers, surveyors and senior management. The next stage of the research will now focus on the purposeful activity models of each of these groups, beginning with a statement describing the activity system to be modelled, these descriptions are called root definitions.

In modelling the Human Activity System under consideration it is important to produce root definitions that are a) relevant to the problem situation and b) rigorously expressed. This is achieved with the use of purposeful activity models where the move is made from concentrating upon the richness and complexity of the problem situation so far uncovered towards the creation of rigorously derived systems models which express how a set of activities carry out some pertinent action would ideally be organised (Davies and Ledington, 1991, pp 58-59).

Root definitions are used to explore the possibilities available for change in the problematic situation given the culture in which it exists. In SSM the establishment of root definitions is relevant since it expresses the nature of a purposeful activity model regarded as relevant to explore the problem situation (Checkland and Scholes, 1990). Root definitions can be built depending on the different interpretations of the purpose of the subject matter, it is the

'worldview' taken from the beginning that gives meaning to the 'transformation' process. To ensure the exploration is thorough, or 'holistic', it is always necessary to consider a number of different root definitions. It is also useful to consider two types of root definition: 'issue-based' and 'primary task'. Issue-based models refer to current matters of concern, perhaps the need to be more innovative or to resolve conflictual situations, that cross established boundaries. Primary task root definitions tend to refer to officially declared tasks in the organisation and to give rise to models that map existing organisational structures (Jackson, 2003, pp193-194).

Table 5 provides an overview of the relationship between all of the parties involved in the situation and these are considered to be elements that can usefully be thought about for any purposeful or transforming activity. The idea is that purposeful activity defined by a transformation process and a worldview (T and W) will require people (A) to carry out the activities which comprise the transformation process. The people affected (C) will take as given various constraints from the environment in which T takes place. Owners (O) are those who can change or stop the transformation process.

In order to consider the root definition for the head teachers group it is first necessary to consider the PQR formula which involves doing P by a process of Q in order to help achieve R. This PQR formula provides a useful shape for any root definition so we could identify the head teachers worldviews as a root definition as:-

Utilising available budgets to maintain primary school building assets by using building condition data, energy use, environmental appraisal and occupier surveys to provide a coherent, integrative report including professional advice on suitability and sustainability for the building as a whole and providing a safe, compliant school with well ventilated teaching areas providing the best possible chance of academic success to the pupils.

The extensive, descriptive list of requirements contained within this definition is further expanded by the perspective of the professional and technical advisors differs from the head teachers in that they can be seen to be more focused upon the task of keeping the buildings functional and the school fully operational. They see themselves as providing a service to enable the school to be compliant and safe whilst supporting the head teacher with advice regarding improvement projects. They generally feel that head teachers would find it difficult to act upon more information given to them about suitability or sustainability and yet they expressed a

unanimous opinion that certain aspects of the environmental appraisal would be very beneficial in improving the building and its use. It was also generally accepted by the surveyors that the issues of suitability and internal environment are inseparable from their input and that some training and practice guidance could enable them to make a more meaningful contribution in these areas. Checkland and Scholes (1990) suggest that the root definition should be constructed from the worldviews by taking into account the following CATWOE as explained earlier. The CATWOE concept and can be seen as stepping across from the real world situation into the systems thinking world.

View point	Head Teachers	Teachers	Building Surveyors and Engineers	Senior Managers
Customers	Teachers, the pupils and Governors	The Children/pupils	Head teacher teachers and the pupils	County councillors, head teachers and governors
Actors	Senior Managers, Practitioners, School Governors teachers	Head teacher, the practitioners	Head teacher	The Head teacher the practitioners
Transformation	Improved decision making, improved building maintenance and environment and value	improvements to the teaching environment	Maintaining functionality of buildings, improved practices, improved service delivery and value	overall school improvements, improved effectiveness and value
Weltanschauung	prioritisation of budget to building issues affecting the school	Classroom micro environment, school working conditions and facilities	Professional Practice, information gathering	school asset management practices the quality of educational buildings across the County
Owners	The Board of Governors	The Head Teacher	The Head teacher, the school Governors	The Head teacher, the school Board of Governors
Environment	Building asset management, The staff, the pupils, the Governors, statutory and financial controls	The teaching environment, the pupil achievement	Building asset management, legal compliance, H&S and Building regulations, school budgets	Building Asset management practices, budgets, politics, legislation.

Table 5; CATWOE analysis of the problematic situation

Using the PQR formula the surveyors and engineers root definition might be expressed as follows:-

Maintaining school buildings to a standard required by Building Regulations by providing technical advice to head teachers and advising on priority of work from building condition data relating to H&S, statutory requirements to enable buildings to remain functional.

Whilst this statement has less content than the headteachers root definition it carries an overlapping content with much commonality with the head teachers position.

The worldview of the senior managers is broader than the others and is couched in school asset management practices and the continuous pursuit of better efficiency and value. In considering the CATWOE analysis shown in table 5 we can think of the senior management perspective as being one of an overviewing control although they cannot be seen as owners. They held the carrying out of condition appraisal as being of vital importance whilst accepting that it would involve collecting data that would not be used and that at some stage changes would be required to address this situation. They also demonstrated great faith in the relationship between the district surveyors and the head teachers asserting that this was the best way of making things work. Statutory compliance and resolution of H&S issues was regarded as a must and sustainability seemed laudable but totally out of reach financially and proving to be a low priority. Suitability and occupier feedback was generally regarded as having little worth. The Root definition therefore seems to clash with the head teachers and, to a lesser extent, with the surveyors. It could be represented as :-

Directing the property group resources into pursuing acceptable asset management practices by instigating the collection of condition survey data, measuring internal environments, pursuing a low carbon technology strategy in line with the sustainability strategy of the authority in order to achieve a satisfactory standard for all primary schools in the county's control.

From these root definitions we can now consider the purposeful activity models for each group. Every real-world problematic situation contains people who are endeavouring to act purposefully that is to say not just by instinct or arbitrarily. A soft systems approach to this scenario is to treat this purposeful action as a system. This system contains a logically linked set of activities which have an adaptive 'whole' whose emergent property is its purposefulness. In the case of the head teachers group the purposeful activity model may comprise the 12 activities outlined in figure 6.

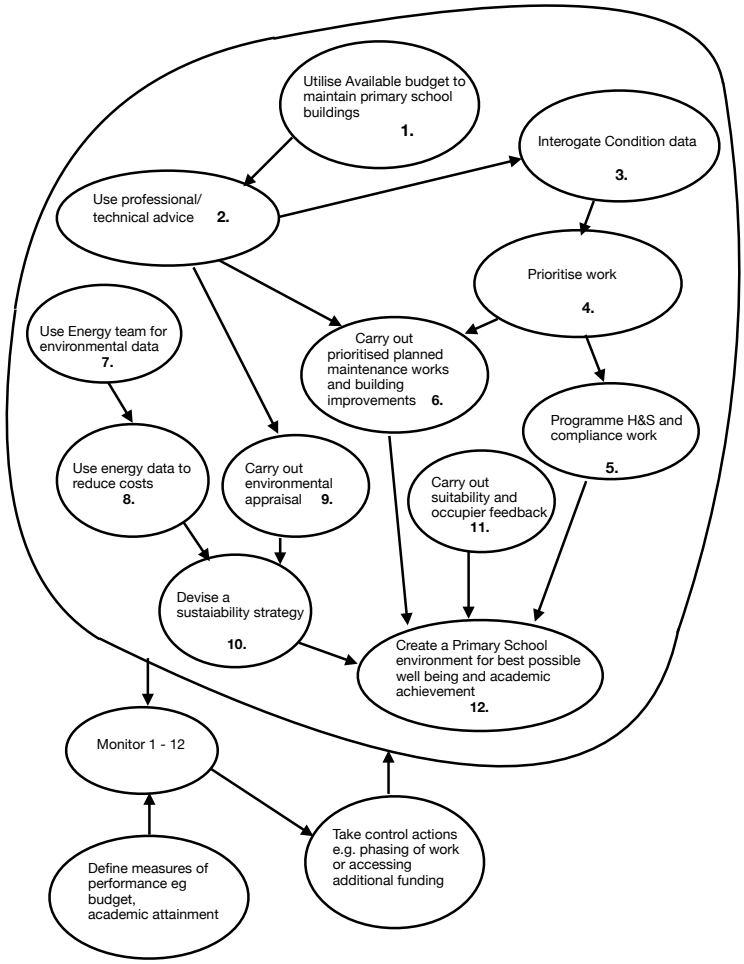


Figure 6: Purposeful activity model - Head Teachers group

Starting with the first activity taken from the root definition the activity node 1 would identify the scope of the task from this all activities identified from the interviews of the group and the root definition are arranged in an approximate order to achieve the objective as contained in the root definition i.e. to provide the best possible environment for well being and learning within the school.

The activities are relevant to the situation although containing some activities which already take place but also containing the desirable content from the head teachers interviews. The process of compiling this model prompts questions about the differences between the model and the situation and enables consideration to be given to whether it would be desirable for the situation to be more or less like the model.

The purposeful activity model for the surveyors and engineers takes a different and less complicated view which is shown in figure 7. Here the primary activity is considered to be maintaining schools to a minimum standard required for compliance with the Building Regulations which was a finding from the interview analysis of the surveyors group. Whilst there are similarities with the head teachers model the surveyors objective was to provide a fully functional primary school and there was an expectation that the Energy Team would carry out not only the energy appraisal but also measure the environmental conditions.

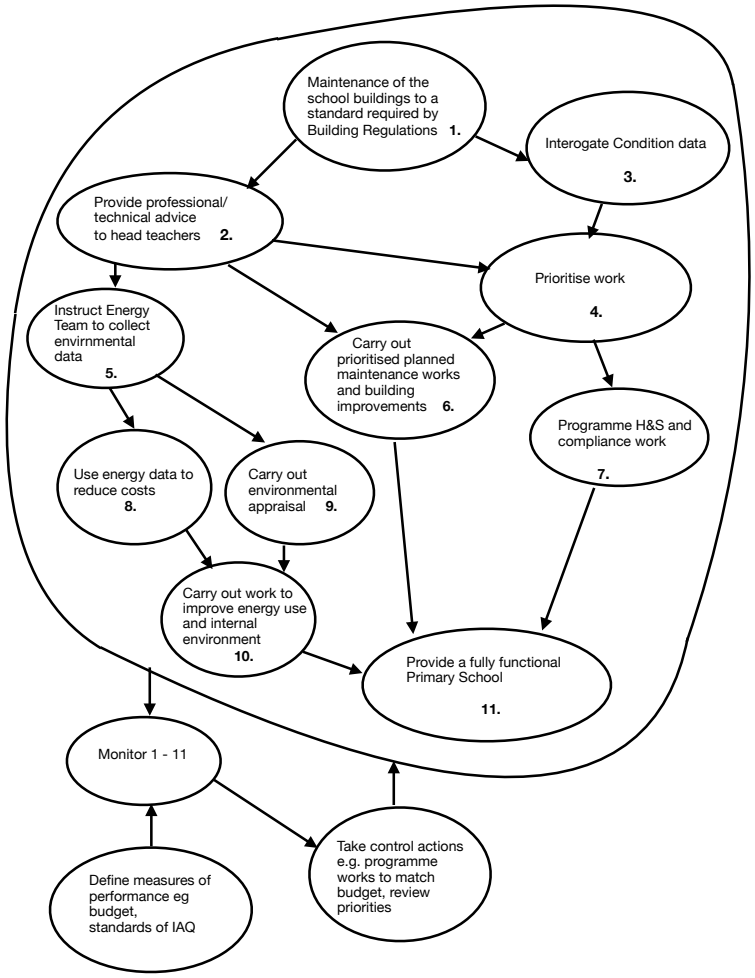


Figure 7: Purposeful activity model - Surveyors and Engineers group

The proposed performance measures of budgets and internal air quality could be added to and include such things as fulfilling the county QA procedures or work being completed on time and to an agreed standard.

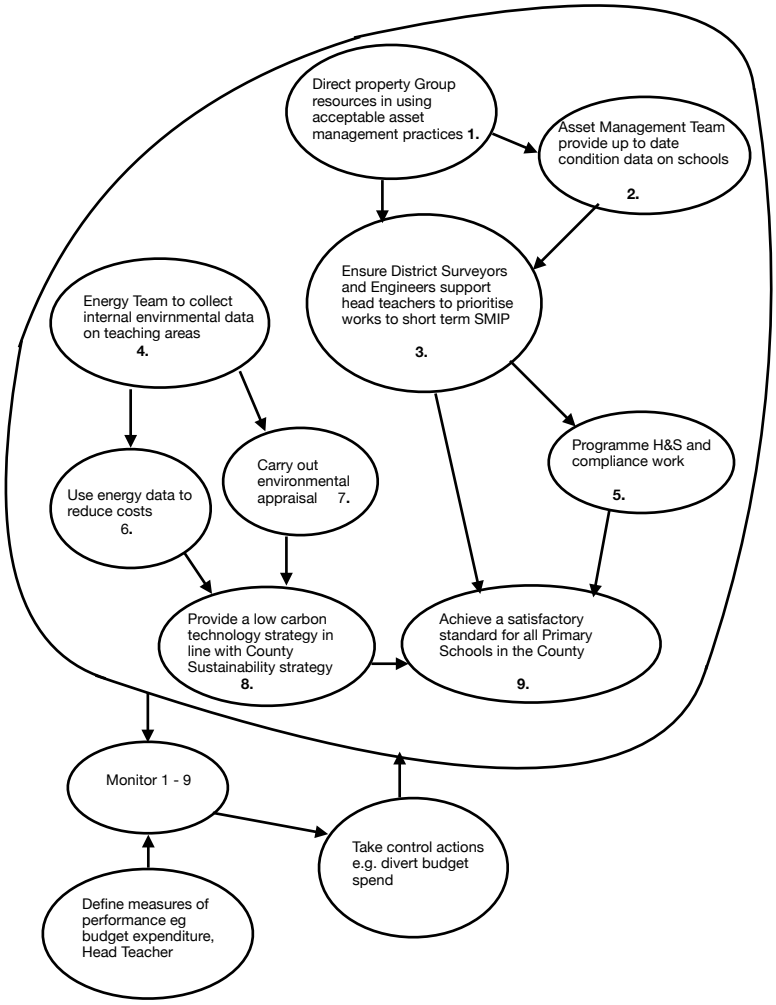


Figure 8: Purposeful activity model - Senior managers group

The senior management model has been illustrated in figure 8 and shows the primary task as being to direct the property group resources using acceptable asset management practices (ie

those recommended by the DfE). The asset condition information was identified from the interview analysis as being of some importance as was the relationship between the District Surveyor and the Head Teacher. It was an intention to align the property strategy to that of the county with regard to sustainability and internal environmental appraisals and energy assessments were clearly identified from the interviews. The objective of the senior management was identified as being the achievement of a satisfactory standard measured against budget expenditure and head teacher satisfaction which is gathered from surveys and review meetings between senior management and a representative group of head teachers.

Each of the purposeful activity models represents one way of looking at the real world situation providing multiple possibilities to be questioned and considered by comparing with the reality. This situation can now be explored with a view of looking for an accommodation which has been defined as *'a version of the situation which different people with different worldviews could nevertheless live with'* (Checkland & Poulter, 2006, p11).

This accommodation can be represented by the construction of a conceptual model using a summary of the results from the initial study, the existing POE practices from the literature and the purposeful activity modelling. This conceptual model will be developed to a stage which could be applied in practice. The model demonstrates how the conventional methodology and the content of the POE can be combined in a BPCE process, this is outlined in figure 9. It demonstrates how the existing POE/BPE methodology (the green boxes) and the existing building maintenance processes (the red boxes) are included in a revised process. The model indicates how the questions raised from the purposeful models have been answered by either an acceptance of a proposed technique and its inclusion or by deciding that there is insufficient support for the technique and its exclusion. The findings from the research carried out to date fits in with what is already known.

The first stage in the model involves the review of the building condition information and this is then revised into what work must be completed to satisfy statutory and H&S requirements. Items which may affect the building performance are then considered e.g. replacement windows, envelope insulation etc. Those items that can be considered 'house keeping' i.e. those subject areas where the head teacher and the staff will decide as to what is required and to request its

inclusion on the planned works programme. This type of item will then in future be removed from the condition survey and only be raised by the head teacher when a decision has been made by the school to ad them to the programme.

The next stages involve the Energy and Environmental Audits, these are carried out and their results presented for consideration alongside that of the condition data. This part of the exercise strongly resembles that of the POE but the results are analysed in conjunction with the condition information to see where they overlap. It may be possible to see that by resolving a particular building condition issue another building condition issue can also be resolved. This can be seen as simultaneously solving problems or supporting the remedy of one issue over another in the prioritisation process. Where there is no overlap the importance of resolving a building performance issue compared with a building condition issue can be appraised. What requires prioritisation is the feedback data from the occupier survey this is an important exercise to determine what work is to be included in the planned programme of work. This will involve a careful scrutiny of the feedback with the head teacher and when a decision has been made to carry out any work identified a process devised to inform staff of how the decision was made regarding issues that they have identified or suggested and how they will be prioritised in the future.

From the bringing together of all of this data the school maintenance and improvement plan is produced that captures the work required over a shorter more focused period and in line with the available school budget. The format for this is likely to be similar to the management and review document used in the existing process and this is the essence of the Building Performance and Condition Evaluation.

The works identified for the first year are then procured and completed and this is followed by an evaluative stage where the Head Teacher and the school governors can input a view as to the benefit of the process together with the professional advisors. This is an important evaluation as it will have been tested about what contribution the findings make to improving the process, improving standards and adding value for the school. The final stage involves revising the building condition survey so that the cycle can be repeated.

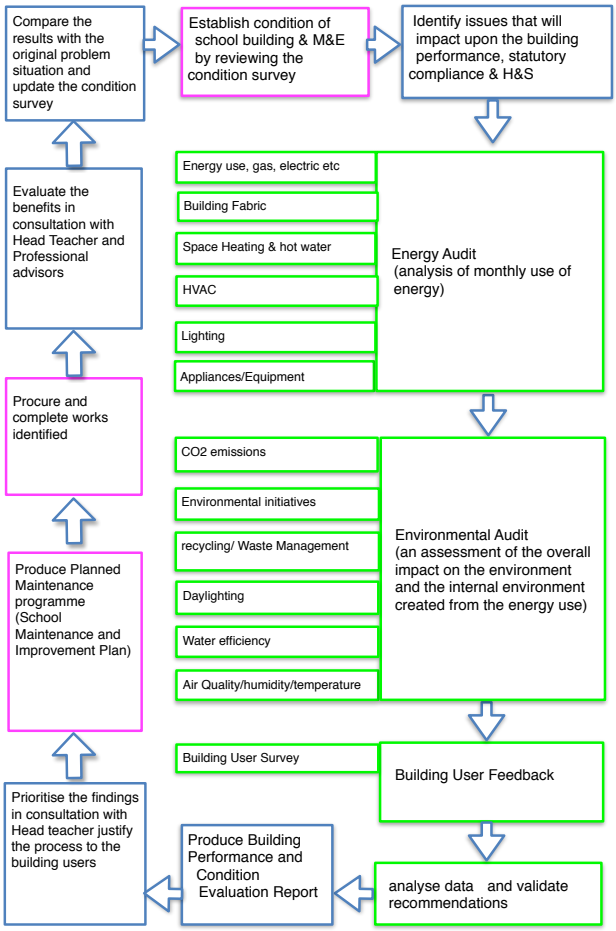


Figure 9: A conceptual model for the implementation of the BPCE process

This is also a radical change from the existing process in that the condition survey data is kept alive and constantly reconsidered and re-prioritised. It could result in the condition survey not

being repeatedly carried out at great expense to the Authority and the condition data much more carefully managed by those closely involved with the process.

In deciding on possible changes to improve the situation they must be arguably desirable and culturally feasible for all of the groups and the exercise has presented some good examples of where activities across the groups can be satisfied simultaneously.

The next part of the research will involve an assessment of the performance of the combined model, the conceptual model developed so far, against the five Es criteria. In order to do this an integrative framework has been devised which will enable a rigorous analysis to be carried out.

6.0 An Integrative Framework for evaluating the BPCE

6.1 Introduction

There are many contributions in the literature that focus upon the POE and BPE and the useful outcomes and opportunities to improve building performance, sometimes at very low cost. The usefulness of carrying out a full POE or BPE has been demonstrated and they are clearly worthwhile in their own right. However the objective of this research is to see if the techniques that have been developed would offer an improvement to the conventional asset management process. The aim of this study is to investigate how a Building Performance and Condition Evaluation could be used to improve current Building Maintenance and Asset Management processes and, most importantly, the end user experience in Primary Schools in the UK.

The main research question to be answered is that if the conventional building condition appraisal were to be carried out in conjunction with other evaluative techniques what would be the benefit to the overall asset management process and what improvements could be expected in the building performance from the adoption of the revised method, the Building Performance and Condition Evaluation (BPCE) as shown in the conceptual model in figure 9, chapter five.

The process of identifying a standard BPCE for primary schools will involve the prioritisation of issues which are identified as legal requirements such as ensuring that the electrical hard wiring installation is safe by carrying out testing at five yearly intervals or gas safety testing and legionella testing. These issues are the core activities in any condition appraisal and is where they are in the current regime and they would need to remain at the forefront of any BPCE. the efficiency of these activities are therefore considered to be constant and unchanging. Those issues that impact on the physical needs to maintain the building envelope, which are also considered to be urgently required and essential in enabling the school to continue operating will also be viewed as constant.

The initial study of the current practices and opinions of those involved with the management of the primary schools has provided an insight into the problematical situation that exists and those areas where there is an interest for all of the parties involved as well as where there might be some divisions of opinion. This problematical situation has been is therefore the starting point which has been used to shape the root definitions and construct the purposeful activity models. From this a single conceptual model has been developed. The integrative framework will now be

used to bring together all of the issues involved and to evaluate the BPCE method as described by the conceptual model. This will then arrive at the proposed BPCE which can be used to carry out actual evaluations of a number of primary schools and then be examined further by gathering feedback from the head teachers. The last stage of the research enabling the desirable and feasible change to be identified.

6.2 A framework for evaluating the BPCE using the 5 Es

The next stage of this process is to develop a conceptual framework focused on the content of the BPCE which is derived from a review of the findings of the initial study and a further detailed examination of the BPCE process as illustrated by the conceptual model. The starting point is Soft Systems thinking and its approach to quality (Vigden, Wood-Harper and Wood, 1993). This can provide the basis for structuring the BPCE in the specific context of primary school asset management. SSM is concerned with improvements to problematic situations through the transformation of 'inputs' to 'outputs'. The input here will be the existing problematic asset management process as identified by the initial study interview data and the output will be the refined and improved process with the transformation being achieved by the application of the BPCE and the process surrounding its use.

The primary school scenario contains a number of parties that would be affected by the decision to adopt the BPCE and a summary of these is presented in table 5. The viewpoints of the premises managers, practitioners and decision makers are considered and who they perceive to be the customer, the actors, the transformation process etc are considered. The inclusion of the teachers has been made to complete the whole picture for primary schools. Some common ground has been established through a multi-perspective approach identifying where the different views could be accommodated whilst endeavouring to maintain the objective to improve the quality of any decisions.

The next step will be to use the 5 Es criteria to judge the success of a transformation to a recognisable improvement. Each criterion defined will then be operationalised by dimensions that may be applied in practice. The first stage involves the assessment of the BPCE and its associated process with regard to efficacy.

6.3 Efficacy

The first of the 5 Es criteria to be considered is Efficacy which poses the question 'does the transformation work? Does the means work?' (Checkland and Scholes, 1990 p 39). Putting this is the context of BPCE, efficacy would translate to the implementation of BPCE decision making in practice with desired improvements as outputs. This implies the use of mechanisms of control and evaluation without which, efficacy of BPCE decision making cannot be ensured.

If we consider the transformation process as being the change from using the present techniques and methods to one where there was enhanced teaching conditions, greater value achieved in the expenditure of the school budgets, improved sustainable practices and better processes in gathering higher quality data which would result in better decision making, then we have the basis for making a judgement about the efficacy of the BPCE.

If the principal aim of the BPCE is to identify the standard of building performance and maintenance needs of a primary school then in order to measure its performance with respect to efficacy it is necessary to consider how the optimum situation referred to above would be achieved. In considering this reference can be made to the findings from the initial study and the aspirations of the head teachers for their schools. The initial study engages all of the parties to consider the present situation i.e. just the Building Condition Survey (BCS) and the planned maintenance programme produced from this containing a prioritised set of works over a ten year period. It then invites comments from the premises managers regarding the use of other methods and to consider what their preferences would be. It therefore follows that in considering the efficacy of the new BPCE, being able to propose the use of certain techniques and methods that would achieve the desired aspirations would offer an indication of its likely success.

What was concluded from the initial study was that changes could be made to simply support what was for the most part current practice and so the proposed BPCE can be designed to achieve this but also to offer some further benefits that the Premises managers were largely unaware of and yet they were very interested in when they became aware of them. In order to fully consider the efficacy of the BPCE its content would need to be considered in its constituent parts as shown in the conceptual model on page 95, i.e. the Condition Appraisal the Energy Audit, the Environmental Audit and the user feedback. The Transformation can be considered to be the change from the existing practices to the new BPCE methodology. The Weltanschauung is

the prevailing culture of the head teacher as the budget holder, requiring the approval of the board of Governors and the Local Authority providing the professional support.

6.3.1 The Building Condition Survey

The assessment of the efficacy of the change with regard to the BCS would be made by looking at the current practice and then comparing this to the outcome from a new process. The new process would involve a much reduced planned programme for building maintenance work compared with what is being currently adopted by the schools. The current survey reports upon large quantities of material that is not used and the SMIP is produced in liaison with the district surveyors and the head teachers this would typically be a three to five year programme. The BCS currently provides a commentary on twelve major elements and up to seventy sub-elements of the school building. Each will have a priority and a condition rating and include such items as decoration, floor finishes, ironmongery, fitted furniture etc (DfEE, 2000). The priorities range from immediately required to long term beyond five years. This all requires a great deal of time and effort to complete and a very much abridged survey with the 'house keeping' items left to the occupier to consider could be seen as an increased efficacy. In addition to this the BPCE process could offer a way of reducing the cycle of the BCS and, by keeping the data alive with an annual review of the SMIP, lead to much greater efficacy. Increased inspection cycles increases the accuracy of the predictions for required work and enables occupants to agree appropriate standards and achieve better budget management (Howell, 1971).

The current practices have long accepted that the frequency of maintenance inspections should be a ten year cycle and that this a balance between the cost of inspection and the savings made in prevention and the overall repair costs (Seeley, 1976). This latter quantity is a difficult measure to demonstrate and was perhaps a part of the tacit knowledge of the former maintenance surveyors. The head teachers that were interviewed clearly showed that they paid little regard to the large and cumbersome building maintenance programme and survey report and relied on advice from their district Surveyors as to what work was needed and in what timescale. This was often in conflict with the plans that the head teachers had in mind for improvement of the school buildings and facilities. However when the issue of classroom air quality and other building issues that might affect the academic performance of the children was raised their concern was

diverted to understanding what could be done to measure and improve the situation. Clearly any remedial work in this area of internal environmental improvement would enhance the efficacy of the whole process.

6.3.2 The Energy Audit

The measurement of the energy usage and the comparison with other similar types of building is a widespread process and currently used in the provision of a Display Energy Certificate (DCLG, 2008). The process requires the examination of the energy use over a one year period and makes allowances for certain separable energy uses which present unusual high loads such as Bakery ovens, sports floodlighting, regional server rooms etc. The more detailed examination involving the analysis of monthly energy use and the breakdown of this use into component parts for heating, hot water, appliances, lighting, etc enables a much greater understanding of the situation and enables the use to be much better managed. In asking the question of the present situation; does the process of energy management work? the response would be no, however, with the provision of the analysis within the BPCE there would be a much better opportunity to engender a management that would produce savings and an enhanced efficacy would be evident.

6.3.3 The Environmental audit

Although the head teachers showed a considerable interest in the environmental performance measures in the initial study it was evident that the pursuit of any environmental objectives would need to be prioritised with a great many other issues. It is difficult to anticipate to what depth the BPCE would need to capture information regarding the environmental performance and it would depend on a wide variety of factors whether it would feature to any degree in the final recommendations. Issues regarding building sustainability have been widely accepted in the UK and it would be very probable that the school would understand what the CO_2 emissions for the school were as this would be stated on the DEC for most schools. They may also know what the water usage for the school was and and how efficiently waste is being managed. The question of whether the process in place is producing the desired result depends upon how well defined the desired result is and in the case of the initial study the schools presented a wide variety of involvement in environmental issues. It would be safe to say that the objectives of many of the schools was based upon the need to be making efforts to conserve resources and the

BPCE would offer them a much improved capability to understand and manage their energy resources.

It was established that many schools would want to have specific checks made on the classroom air temperatures, relative humidity and CO_2 levels as well as have some feedback from the occupier survey regarding thermal comfort and air quality. The means of acquiring this data can vary, but the use of one simple data-logging device with a +or- 5% accuracy (Q-TRAK IAQ Monitor or the Extech SD 800) to gather CO_2 concentrations, humidity and temperature located in a classroom for at least one full week of occupied lessons would be sufficient to give a reasonable indication of the conditions. This exercise could be repeated for two or three further classrooms preferably simultaneously and then a comparison of the three sets of classroom data would enable a judgement to be made for the school. Whilst there are more intensive scientific methods which are likely to produce a more accurate and reliable measure and involving taking measurements in multiple locations within the same classroom, this method is still much more useful than taking spot measurements. The data obtained by this method will provide a reasonably accurate assessment of the prevailing conditions and this process is reliable to provide good consistency over time if calibrated regularly (Lee and Chang 1999).

6.3.4 The Occupier feedback

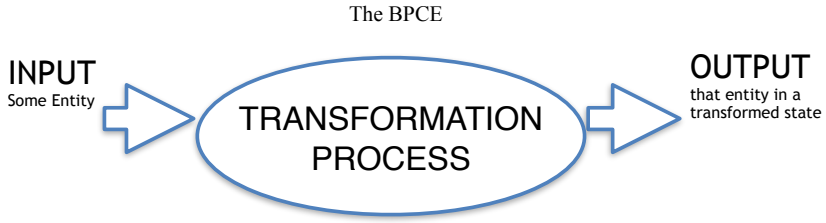
The data gathered by using the occupier survey provides a subjective appraisal of the performance of the building made by the people who are using the building. If the goal of any building performance evaluation process is to improve the user experience then this data is of the utmost importance. In considering the the efficacy of this part of the BPCE is may be considered necessary to ensure that the survey asks the right questions and provides the occupier with every opportunity to consider their views of the building. Borders and Lehman (2005) have developed a standard format survey for capturing user feedback which has been refined since its first use in 1981 which uses a simple Likert scale to record the responses. This type of survey method to obtain occupier feedback has been identified as only offering a limited ability to determine causal mechanisms but will give a good overview of the situation and some correlation within and between buildings, (Gossauer and Wagner 2007).

The data gathered from the occupiers can look very subjective when viewed by the individual issues raised but it can collectively define serious issues with the building performance which can indicate a major building failure. This process is absent from the existing situation and the inclusion of the occupier feedback in the BPCE offers an additional means of acquiring data about the building and the occupier experience and ultimately resolving both building performance and condition issues

6.3.5 Operationalisation of Efficacy

Operationalisation is a process of defining the measurement of a phenomenon that is not directly measurable, though its existence is indicated by other phenomena. The goals of overall asset management and user satisfaction are areas where the required outcome can tell us something about the efficacy of the process. At this stage there is a need to consider what techniques are likely to deliver the required result or output using the initial study data and by reviewing the literature. There is also a need for monitoring, quality control and standardisation of the process to be adopted. The decisions made at this stage can then be carried out with the outcomes examined further through a number of BPCE Reports from the selected group of primary schools.

Figure 10: The idea of 'Transformation Process' adapted from (Checkland & Scholes, 1990)



A defective building	-to-	A building with correctly prioritised defects remedied
Stuffy classrooms	-to-	Classrooms with alert children and teachers
Asset management	-to-	Enhanced Asset Management
Unhealthy school premises	-to-	Healthy buildings

Maintenance of school buildings -to- Maintenance of school building met with good building performance

The efficacy is tested by examining the question asked by Checkland & Scholes (1990, p39) 'does the means work?' This is perhaps a vital consideration for this research as it questions the output of the given transformation process in creating overall improvement. How is this improvement to be measured? Its success will only be fully determined in the practice and the gathering of opinions from those who will receive its benefits or dis-benefits but the assessment will focus on the following key issues:

- *techniques selected which substantiate any corrective actions/desired outputs*
- *information fed back provides easily identified priorities*
- *BPCE system delivers a process of auditing and feedback iteratively which refines the output*

6.4 Efficiency

In order to assess quality in the framework of the 5Es criteria efficiency is defined as carrying out the transformation process with the minimum amount of resources. This can be simply expressed as the ratio of the effective or useful out-put to the total in-put to the system. In order to ensure that this ratio is kept to a minimum the usefulness of the information gained from the applied techniques should be closely considered at this stage and then again in the later evaluation procedures. In many ways the objective of the BPCE is to improve efficiency, that is, to ensure that the output from the exercise is beneficial and well used in the decision making process whilst not placing unrealistic demands on the authority in compiling data of sufficient quality to make good decisions.

6.4.1 Condition Survey

It has been shown in the initial case study that the BCS provides the school with a considerable amount of data for which they have no use and upon elements of the building that they are better placed to make decisions on e.g. the redecoration cycles, the replacement of flooring and other finishes, lighting upgrades etc. It is with the intention of making the process more efficient that this type of material could be removed from the content of the survey. In addition the planned

programme timescale could be shortened (the provision of long term maintenance costs for asset management purposes, should they be required, would then be a separate exercise) which would increase the focus on what was needed and improve the quality and detail of the information provided. The process of annual re-evaluation of the short term maintenance programme provides an opportunity to manage the input from the building condition survey and to keep it under review. The increased efficiency is embodied in this part of the BPCE process of distilling the condition data and using the resources to other areas of the BPCE where perceived value is greater.

6.4.2 Energy audit

The Energy Audit processes was seen by a number of premises managers in the initial study as being of value when considering where to focus to achieve energy savings. To see how energy use is broken down in the school provides Head Teachers with an understanding of how much energy and cost is expended in the areas of Heating, hot water, lighting, the school kitchen etc. It provides them with the benchmark of other similar buildings so that they can see how they perform against other similar establishments. Most importantly the degree day analysis and the comparison of energy us with number of days when the school is in full occupation provides an opportunity to investigate usage against estimated requirement. This enables problem areas to be identified and high use situations to be further investigated and the likely outcomes of this part of the BPCE would lead to a more energy efficient school.

Where low carbon technologies have been provided to a school the detailed breakdown of the energy use provides a greater appreciation of the impact of renewable energy systems, good or bad. It also provides an indication of what kind of renewables would suit the school best if they were considering an investment. The energy assessment requires a detailed survey of appliances and lighting and a series of desktop calculations using the schools energy bills and weather station data on external temperatures to complete the exercise and this will have a cost implication. However, those schools that realise they are in a high use category for annual gas and electricity use per m2 (from the DEC) would clearly be well advised to find out why and to look for ways of reducing their energy use. This could be achieved by carrying out a full energy audit. Most Head teachers were keen to understand more about the detail of their energy use to assist in making decisions in how the school is run and to consider the level of heating etc, in conjunction with the user feedback survey information.

6.4.3 Environmental Audit

The process of gathering the environmental audit data would be a completely new addition to the existing process and so any assessment of its contribution to improved efficiency must focus upon the identification of undesirable situations that currently exist and the opportunity to improve them. The measurement of internal conditions will provide head teachers with information about teaching areas that they may wish to act upon in an attempt to improve the academic performance and well being. In answering the question of 'what is to be gained from applying the resources to conduct the Environmental audit'? the answer will largely depend upon the value attached to the results and what the likely actions will be taken to redress any problems identified. In may ways this should have no bearing on overall efficiency as this is not currently being looked at but the resource to carry out this exercise could be seen as utilising the resources saved in not capturing unused data from the condition survey.

The comparison of monthly water use and occupied school days provides a means of viewing the water use to see if the usage patterns are regular. If there are periods of higher than expected water use then it provides the opportunity for further investigation. If it is shown that the school has a much higher than average water usage then further investigation into where water is being lost can be instigated or the school may wish to consider investing in some water saving measures. The efficiency of the environmental audit process within the BPCE must be judged on the establishment of good levels water use compared to an appropriate benchmark and a water use strategy which is monitored by the process. The evaluation of the efficiency of this process has a starting point of high or unknown water use and an end position of good water use and a monitoring regime. The justification for devoting the resources to this problem could be evaluated in the reduced cost and environmental impact of saving water with future monitoring carried out by the school.

6.4.4 Occupier Feedback

The content of the building user survey has been designed to be sufficiently broad and investigative so as to try to ensure that there is a good balance between the resources deployed and the usability of the data generated. The point of asking people questions about their environment is that their views on how the building suits them is important. It involves the user,

even the disinterested user, with the management of the building and invites them to make a statement that they are content with their environment or they wish to change it. If from the outset there is no possible action to be taken to remedy any problems that might be identified then the survey should not proceed but this is rarely the case. The data may provide some very useful information which can be acted on at low or no cost and it may identify serious shortfalls in the building fabric or M&E that might need high levels of funding in the future. The survey may reveal that the staff need better training or instructions as to how to operate the building, e.g. heating controls or how to make the ventilation system work better. Making decisions from the feedback must be well communicated back to the contributors in order to avoid any demotivational issues but carrying out works to rectify users issues can be rewarding and highly motivational for the occupier. In some ways the efficiency of the occupier feedback can only be fully assessed when the findings are considered however, the transformation instigated by this process has a starting point of no consultation and an endpoint of staff consulted and involved. Once this process is accepted then like other techniques currently not used the efficiency of this part of the BPCE process should be judged on whether the time and resources devoted to the action can be justified as using the minimum of resource.

The balance of whether it is more efficient to proceed with a detailed set of questions in an anonymous questionnaire or whether the Head teacher gathers feedback from the staff through meetings, random conversations or even a complaints and suggestions process is a subjective matter. However it is gathered the feedback is a useful way to compare the results from other parts of the BPCE and it is highly likely that some of the issues raised would be resolved by actions taken to resolve a building performance or condition issue found elsewhere. It therefore has an additional value in supporting or contesting decisions on impacting issues. If it is accepted that any form of feedback from the building users should be acted upon, i.e. in the normal course of using and maintaining the building and reporting defects, then to devise a systematic way of collecting this may prove to be more efficient than the random, haphazard approach currently deployed. So as to understand whether the efficiency of the BPCE occupier feedback technique is acceptable this contrast needs to be made.

6.4.5 Operationalisation of Efficiency

The resources that are used in the production of the BPCE are difficult to accurately assess as they would be varied and dependent on the content and complexity of the activities involved for

the particular building under evaluation. They would depend on the time spent in deriving the data and the amount and sophistication of the equipment to be used to capture the data over a given time period. The carrying out a number of BPCEs for a mixed group of primary schools would offer the chance to measure up the inputs for different schools and then assess the value of the output for each case. This would enable a comparison to be made of the different schools and for conclusions to be drawn from the outcomes. The overall production of the BPCE involves four main areas of evaluation the condition, the energy use, the environment and the occupier feedback. These are each carried out with a degree of efficiency which is identified by the extent of the input from all those involved in compiling the report and an assessment of whether these adopted methods represent the minimum amount of resource that could be used to achieve the desired output. In looking for good indicators of the efficiency of the process any wasteful techniques would need to be identified and avoided and the satisfaction of those involved in the process is high. This would appear to be a key test of efficiency i.e. in what way should things be measured so that the providers of the data achieve findings that are satisfactory and able to lead to actions tailored to the available budgets? The key measures are therefore:

- *activities are carried out to specific purpose*
- *all collected data has a justified, valuable use in decision making*
- *outcomes provide widespread satisfaction with users*
- *possible alternative solutions for gathering data are adequately considered*

6.5 Effectiveness

Using the theory of the five Es criteria to judge the success of the transformation we can think of the effectiveness as the transformation process performed by the system meeting the longer-term aim (Checkland and Scholes, 1990). Effectiveness in this context can be seen as having a strategic character with the overall objective being to take a view of the Transformation which is focused on the longer term objectives. This is a clear distinction from the efficacy (producing the required outcome) and efficiency (carried out with the minimum resources). The issue of how to consider the effectiveness of a system in its use in a particular environment is to ask the

question; will it produce the required output over the longer term? or is the Transformation meeting the longer term aim?

6.5.1 Condition Survey

The current process involving just the building condition survey to manage the asset has been identified as not being effective. The reasons for this are as previously stated the inclusion of data which is not used and trivial in nature. The BPCE process proposes to be more effective from the start of its implementation by capturing all of the relevant and the long term data of the condition survey and distilling it down to a three year view. The process of refinement of the condition data will require the input of the head teacher and their professional advisors and it will involve the prioritisation of the work identified outside of the mandatory statutory and H&S issues. The long term objective for the survey data is that as the high priority works are completed and removed from the data new items of prioritised and costed works from the data are added to the three year programme. The programme will then be reviewed every year and the condition data will be re-evaluated and re-prioritised. This process of continuously capturing the three year view will gradually erode the condition data that is gathered on a 5-10 year cycle whilst at the same time keeping its content under a continuous examination.

6.5.2 Energy audit

In considering the effectiveness of the Energy audit it is important to look at the approach that is being used and the questions that are being answered. How much energy does the building use? Where is it being used and in what proportions? When these questions are answered consideration should then be given to what efficiencies and savings can be made and in some cases what changes could be accommodated in the operation of the school if they could result in savings e.g. reducing the temperature in some areas an perhaps overall by one or two degrees.

This section of the BPCE has a short term outlook in the analysis in that it examines the building performance over the previous year and identifies the level of performance and the need t make changes or carry out further investigation. If the investigation identifies only small savings then in these can be significant in long term. The repeating of the exercise in measuring, for example, the gas used for heating would be a way of monitoring the energy use and continually maintaining the savings and developing the methods of energy conservation that are being

deployed. The transforming process here then offers a great deal more effectiveness than the current situation provides.

6.5.3 Environmental Audit

The environment audit is centred upon the internal environmental conditions that the school is delivering from its energy use. This is an entirely new process with no measurement of air quality having previously taken place. The initial survey showed a very strong belief in measuring and improving internal environments especially in teaching areas. The process is very likely to generate some remedial work which would be prioritised against other possibly urgent works derived from the condition data. It seems very likely that some of this work will proceed at the request of the head teacher. This situation can be compared to the longterm effectiveness of the current method of just deriving work from the condition data and the head teachers requests. The measurement and evaluation technique has led to a revised priority being fulfilled and thereby demonstrating an improved, more effective prioritisation process.

The longer term objectives of the environmental audit are likely to involve a monitoring process even where corrective action has taken place to resolve any issues. Measuring and recording indoor environmental measurements will identify if the school is operating within good practice guidelines. The school would have a need to be aware of the performance so that they're operating practices in the future can be justified or improved. The checking of CO_2 levels in teaching areas is an example of where there are good guidelines such as Building Bulletin 101 (HMSO, 2012) where recommended minimums are stated and warnings made about teaching in high CO_2 concentrations.

6.5.4 Occupier Feedback

The long term effectiveness of carrying out a user feedback survey on the transformation process is difficult to assess as the survey offers a snapshot in time of the building performance on the occupiers. However, if the data collected can be used to justify action or indicate that no action is required in the future or that further investigation into particular issues will be necessary then it will be achieving a long term objectives. If occupiers are aware that their opinions are valued in the process by seeking their opinion and acting on it, even if the prioritisation exercise leaves the matter confined to the medium term, they will know that their opinion matters and they can affect outcomes. It is also important for primary school teaching staff to know that their concerns

for their teaching environment are based upon providing good conditions for learning. As such the feedback of this type should be given an important priority over other non-urgent types of building work. This conveys the important message that the well being of the occupiers and the provision of better teaching conditions is part of a long-term asset management strategy (Egan, 1998).

6.5.5 Operationalisation of Effectiveness

The transformation of the existing processes into the new BPCE leads us to consider how durable the newly adopted process will be and can it be seen to be meeting the long term aim? Better decision making is a very worth while long-term goal for all schools with regard to their asset management processes and particularly the management of building maintenance. Long term effectiveness with regard to building maintenance could be assessed with regard to the clarity of the process for identifying and prioritising work. The development of such a regime would allow strategies to be devised which would serve the school well and be seen by improvements in the quality and timing of the decisions taken. It would also manifest itself in the improvement in value obtained from carrying out the right work at the right time and identifying the correct priorities for the improvement of the overall performance of the school. The effectiveness of the BPCE and its associated process would therefore be a substantial improvement on the current arrangements. The key assessment criteria are:

- *decision making incorporates the findings of the BPCE*
- *data is accurate and reliable*
- *data gathered is relevant for the purpose to which it is being put*

6.6 Ethicality

Vickers (1965) states that judgements based upon ethicality concern ‘good’ and ‘bad’ judgements which are subject to change over time. This could be further explained by the suggestion that moral goods expand and improve on the human condition and moral bads or evils degrade it (Mason et al, 1995). Ethical thinking suggests that society needs and uses moral standards to avoid chaos and is based upon ethical theories and principles. There are two broad

streams of ethical theory Teleological and Deontological each involving different trends. Teleological or 'consequentialist' theories, as they are sometimes referred to, see a 'right action' as one which has overall good consequences and a 'wrong action' as one with overall bad consequences (Vesilind and Gunn, 1998). Teleological theories can be centred on the agents themselves or on the results of their actions. When centred on the agents themselves they look at the evaluation of motives, knowledge, truthfulness, fairness etc and also whether the agent should be considered responsible for their actions. When centred on the outcomes of the agents actions they focus upon the public interest and interpret the results of actions in the light of its consequences for stakeholders. They are used to evaluate the overall outcome of a programme and the effects on the stakeholders involved (Mason et al, 1995).

Deontological theories derive from the Greek 'deon' which means duty or binding. These theories are centred on the act taken by the agent and the duties, principles, and responsibilities that pertain to the act. They presuppose that a set of rules exist which define what is right and wrong. Deontological Theories are non-consequentialist as they are opposed to the value of consequences in evaluating rightness or wrongness and actions are therefore right or wrong independent of the outcomes.

There are a number of ethical issues to be considered with regard to the transformation from the current asset management scenario to one where a BPCE is applied. Perhaps the central issue is that if the overall objective is identified as providing the best possible learning environment for primary school children then this can be seen to contain some moral obligations. Ethics provides us with the ability to draw a distinction between 'what is' and 'what ought to be' and ethical thinking is a means of solving a question which might contain inferences of resolution and observance (May, 1983). This raises the question; do all parties have a moral obligation to ensure that they are doing everything possible to achieve an environment that is conducive to learning? such an environment would need to be safe in order to be conducive to learning and all of the legal obligations would need to be complied with in this regard, but is this the limit of the moral obligation as they will only go so far in this regard. Once the moral obligation to achieve the optimum conditions has been accepted there is then the obligation to justify the cost of achieving this in comparison to other obligations of public funding. The cost associated with doing the right thing also becomes an ethical issue in terms of achieving value, what is the extent of the obligation to achieve value for any approved work or project? Who is responsible for the

attainment of value and to what degree and by whose judgement is value achieved? These sorts of questions outline the nature of ethical judgements that need to be made in making the transformation and ensuring that outcomes are justifiably reasonable is the ethical objective in seeking the optimum solution to the problem.

The way that we construct the built environment and they way in which we live in it is a question of prime importance for the preservation and flourishing of human beings but also for the whole of the natural world (Fox, 2000). The subject of 'environmental ethics' has to date been overwhelmingly concerned for the natural environment and ecological issues . However there are a great many important ethically related questions that we can ask about human constructed environments particularly the prioritisation of requirements of form and aesthetics with the functionality and performance of buildings. If we think that there may be something 'in principle' wrong with producing a building that pays no respect to its surroundings or a badly performing building that is disconnected from the purpose of the users then this becomes an ethically based objection. These are ethically based problems that is relating directly to the values that we should live by, yet we have no language or framework for approaching these problems as ethical problems (Fox, 2006).

6.6.1 The Condition Survey

The achievement of agreed standards and of the extent of the collection of data for the purpose of making well informed decisions becomes the basis for the ethical judgements in the compiling of the Condition survey. It therefore follows that this is also the case for the planned programme and the future building maintenance decisions of the school. The measure of what is ethically acceptable is directly related to the amount of resource that is to be devoted to the chosen standard to be achieved. The important aspect of providing the cost appraisal for the planned programme of work will also be based upon the standards to be achieved and the quality of the solution put forward. For example is it ethically correct to propose the use of an expensive, high quality and high performing air handling unit for classrooms when funding is required for other equally important issues within other schools or other areas within the responsibility of the funding body. Finding a balance between what is effective and what is ethically correct in the context of using resources across the estate is important as it would have an impact upon how the benefit is distributed across all schools where a requirement has been

identified. The condition appraisal process within the BPCE enhances the prioritisation process and in doing so delivers a fairer more ethically acceptable approach.

6.6.2 Energy audit

The questions regarding the acceptability of the use of resources to be devoted to the energy audit and the possible remedial works generated from the audit are similar to those of the condition survey. The ethical questions that surround this audit are about the values placed upon deploying the resources to understand the energy use of the school beyond those that may already have been captured by the display Energy Certificate for the school. Reducing energy costs as far as possible to improve the environmental performance of the school and allow savings to be diverted to other important areas is clearly a good practice. It would also be possible to say that this is ethically responsible behaviour.

6.6.3 Environmental Audit

Analysing a situation using ethics inevitably leads to applying several modes of reasoning and the environmental views commonly associated with POE have been considered from the local, the global and the indoor perspectives (Gupta, 2006). Global issues are those which have an impact on the environment generally for example CO_2 emissions and ecological issues whereas the Local issues would be things specific to the site in question that have only a local impact for example water efficiency, recycling, use of materials, etc although these issues themselves have implications on the CO_2 emissions. The indoor issues are concerned with specific measurements of air quality, internal temperatures and the levels of natural daylighting etc. Environmental issues are often associated with sustainability and well being and therefore have a strong ethical and moral component to their measurement and improvement (Papanek, 1995). Environmental issues cannot be considered apart from economic and social issues or from such questions as equity, poverty and human rights (Thaddeus, 1998).

6.6.4 The Occupier Feedback

Occupier feedback has perhaps the greatest significance in terms of ethicality as it is the Health, safety and well being of people that is being brought into question. It is significant in a number of ways including the presentation of the questions to be asked about the building and the occupiers workplace. These can be addressed by small focus groups of people coming together

to collectively address the questions or the questions can be raised by a survey of individual building users. In the case of this research before the questions were asked and opinions sought the contributors were fully informed of the nature of the purpose as being that of an academic study. If the feedback is sought for the purpose of it becoming a part of a BPCE then the way in which the feedback is to be used should be made clear to the respondent. This is to ensure that the respondents know what the likelihood is of their opinions being acted upon, i.e. how they are going to be prioritised with the other issues.

The voluntary participation of people asked to complete a survey is very important as coercing someone to do something that they do not want to is clearly unethical. Perhaps the most important ethical consideration is that no harm, in any form, will come to the participants. They must not be asked to disclose opinions that would make them feel uncomfortable or endanger their home life, friendships, job etc. The clearest concern in guarding the participants interests is the protection of their identity and if it is considered to involve any degree of risk then the information should not be used in any form. The communication of all of the issues around the data collection must be clear to completely remove any possibility of deception taking place as even unintentional deception is a serious ethical issue.

6.6.5 Operationalisation of Ethicality

The transformation of the current asset management process to the use of a BPCE will involve the considering of fairness by considering the interests and concerns of those affected directly and indirectly. Assessment of the outcomes of the transformation should accommodate a process of dealing with concerns, making further information available upon request and offer a line of communication to resolve any problems with completing or understanding the questions in the survey. The BPCE process overall invites some ethical questions and concerns such as the need t report conditions that are discovered to be very severe and possibly an enhanced risk to the health and wellbeing of the occupants. Some of the head teachers in the initial study expressed concerns about the need to disclose severe conditions and whether this would bring about a need to stop using areas of their schools if they were unable to find resources for immediate solutions. The need to consider resolving such matters quickly needs to be looked into and solutions put forward to ease these concerns as once a decision is made to measure a particular aspect of

building performance there is an ethical responsibility to advise those that are detrimentally affected. The key issues in assessing the ethicality of the BCPE can be summarised as follows:

- *Concerns of people addressed*
- *results considered openly in decision making*
- *compromises considered with resource explanations*
- *procedural fairness*
- *increased environmental and sustainability interest*

6.7 Elegance

Is the transformation well designed? Is it aesthetically pleasing? Is it over complicated? Is it over or under engineered? Judgements such as these are generally regarded as being subjective but they allow professional experience to be drawn upon when assessing the quality of the transformation process (Vidgen et al, 1993). The question of what makes something well designed can be demonstrated by considering the effectiveness and efficiency of the solution but also *'the refreshing simplicity and cleanliness'*. Pevsner, (1936) speaking of the Modern Movement and the aesthetics of the work of JFA Voysey.

According to Todt (1997) the reason why the design of many technical systems or products fails to produce acceptable results is largely due the design process itself which is closed off from society who are only able to comment after the system is complete and the major decisions have been made. This theme of the need for greater involvement is embraced by Sanoff (1992, 2001) who presented a series of POE projects on schools which involved multiple data collection methods to assess the performance of school facilities. The POE emphasised the significance of involving the community in the evaluation of school facilities. The ability to encourage input from the building users as part of the data collection process (which is a relatively low cost exercise) and to actively share the outcomes of the process with the users sharing the reasons for making decisions will support the overall success of the Transformation design.

It is difficult to concisely sum up what constitutes the aesthetically pleasing but elegance has been defined as 'the quality of being pleasingly ingenious and simple; neatness' (OED, 2016). A system that displays this characteristic must bring all of the parts together in a neat, simple ingenious way whose ingenuity lies in the effectiveness of its delivery of the desired outcome. The component parts of the system should offer a synergy and a correlation which delivers a solution which is well engineered to fit together and delivers something extra when utilised as a whole, i.e. emergent properties. The emergent properties that are derived from the overall view of the BPCE including the Energy Audit, the Environmental Audit, the Occupier Feedback and the Condition Appraisal are created through an interaction between the four sections. This interaction involves outcomes from each section supporting the decision making process in how best to manage the asset whilst also contributing towards a complete view of a building performing and serving its occupiers activities. The key assessment criterion for elegance in the BPCE can be summarised as follows:

- *all components of the BPCE are compliant with standards of good practice*
- *phases working iteratively provide relevant feedback to other stages*
- *process has the correct balance of social, environmental and economic influences*
- *The process has a clear logical path*
- *The ease in collecting data for the BPCE techniques and the strength of the calculations and numerical definitions.*

6.8 Summary

The conceptual model has been evaluated using the five Es criteria to provide a means of carrying out a structured enquiry into the use of a BPCE for primary schools and a summary of the results is contained within table 6. It is an abstract model of what should be taking place in achieving the objectives which were identified in the root definitions. Each of the criteria have been addressed separately in the context of each of the sections of the BPCE in an attempt to offer up a set of relevant benchmarks to clarify the performance of each part. The key issues in carrying out an assessment of each of the criterion have been listed and will be applied to the next part of the research in carrying out the proposed BPCE to consider the overall success and quality of the process.

criteria	key factors
Efficacy	• *techniques selected which substantiate any corrective actions/desired outputs* • *information fed back provides easily identified priorities* • *BPCE system delivers a process of auditing and feedback iteratively which refines the output*
Efficiency	• *activities are carried out to specific purpose* • *all collected data has a justified, valuable use in decision making* • *outcomes provide widespread satisfaction with users* • *possible alternative solutions for gathering data are adequately considered*
Effectiveness	• *decision making incorporates the findings of the BPCE* • *data is accurate and reliable* • *data gathered is relevant for the purpose to which it is being put*
Ethicality	• *Concerns of people addressed* • *results considered openly in decision making* • *compromises considered with resource explanations* • *procedural fairness* • *increased environmental and sustainability interest*
Elegance	• *all components of the BPCE are compliant with standards of good practice* • *phases working iteratively provide relevant feedback to other stages* • *process has the correct balance of social, environmental and economic influences* • *The process has a clear logical path* • *The ease in collecting data for the BPCE techniques and the strength of the calculations and numerical definitions.*

Table 6: key factors in the operationalisation of the five Es in the BPCE

The transformation is not envisaged to take place in an instant in time but to continue to evolve into the future and to continually refine as outlined in the conceptual model (figure 7). The development of the proposed BPCE and can now be progressed through to the final phases of implementation and prioritisation and then the reflective appraisal of the worth of the exercise with the head teachers. At each of these final stages the appraisal process will continue to apply the five Es criteria to assess the quality of the outcome.

The next stage of the research will involve putting the outcome of this integrative framework into practice by carrying out of a BPCE from the selected group of primary schools. The content and actual data collected from the schools will captured and presented in the example report. This will then be further refined from the second stage of interviews and the feedback obtained from the head teachers from each school.

7.0 Proposed Building Performance and Condition Evaluation Report Format - using the Modern School example

This Chapter attempts to explain the content of the BPCE as it was used for carrying out an evaluation of the modern school building the actual text used in the report is shown in italics and there is an explanatory paragraph before each major section and where further explanation is required for some of the the sub-sections. The same format was used in the same way for the Victorian school report and the appendices contained the same tables and summaries. The report described here is the exact copy that was discussed with four of the ten head teachers.

7.1 Contents

The opening of the report should contain a brief introduction to the property and its essential characteristics providing a backdrop to the exercise. This should not be an extensive or detailed description as the Report will be aimed at the head teacher and others who will already have a good knowledge of the school. The building condition information should be summarised in the first chapter as this will form the starting point of the BPCE. It was considered necessary to identify any works required for the remedy of weather tightness, health and safety and legal issues as being a higher priority than the building performance issues. The building maintenance programme generated from this will be refined later into the School Maintenance Improvement Plan alongside the priorities identified in the building performance evaluation.

The next step will be to look at the three elements of the POE as derived from the literature review in the convention of Energy, Environment and Occupier feedback (Gupta, 2006). This has become the adopted core approach to the POE and BPE methodology and has a logical progression to it starting with an evaluation of the energy use and why it is what it is and what is influencing it. The environment that this energy use is creating is then assessed together with other environmental issues related to the school use and then finally the occupier feedback gives the essential personal yet collective view of the way the needs of the building users are being met. This last exercise can endorse or contest the environmental and the energy measurements. A summary and conclusions chapter then justifies the inclusion of all of the condition and performance issues and derives the School Maintenance and Improvement Plan which takes a three year view. The exercises that have been carried out in carrying out the condition survey

and the occupier feedback which support the proposed actions should be attached to the report as appendices. This leaves us with a contents page as follows

1.0 Introduction

2.0 Condition Survey

3.0 Energy Audit

4.0 Environmental Assessment

5.0 Occupier Feedback

6.0 Conclusions and School Maintenance and Improvement Plan

7.0 Appendices to BPCE Report

Appendix 1 - Building condition survey summary

Appendix 2 - Occupier questionnaire

Appendix 3 - Occupier comments summary

Appendix 4 - Occupier Questionnaire summary

7.2 Introduction

The introduction is directed at the Premises Manager or other support staff at the school e.g. the School Bursar or School Business Manager and their professional advisors. It contains a brief introduction to the development of the process of measuring building performance without further detail identifying the consequences. The Introduction identifies the content of the report and a description of the site orientation and an internal plan showing the location of the dataloggers used in the environmental exercise. The Introduction also describes the construction of the building and its envelope together with the heating system used and the ventilation strategy for the building. An example of the Report provided for the modern school is shown below:-

1.00 Introduction

Since the late 1950s Building Scientists have been looking at the performance of new buildings in an increasingly measured and systematic way. The subject areas known as Post Occupancy Evaluation (POE - often applied to new buildings in use for 1-2years) and Building Performance Evaluation (BPE - which has more generally been applied to older buildings) have been developing since that time and they continue to be refined and used to examine the performance of buildings today. The latest developments of POE have led to the use of a number of techniques which examine building performance in three areas, energy use, environmental performance and occupier feedback. It is the aim of this report is to provide an overall view of performance of the school building primarily in terms of it's building condition but also with regard to energy use, environmental performance, and by taking into account the views of the occupants on how the building affects them. The Building Performance and Condition Evaluation (BPCE) is intended to provide an indication of how well the school buildings fulfil the requirements on all fronts whilst enabling aspects of building performance to be compared and prioritised against more conventional items of building maintenance.

The original Whitefield Infants school was built in 1865 and located just a few hundred metres from the site of the new school which became fully operational in September 2015. The new school comprises nine classrooms, a library area, a studio, an early years classroom and a large hall. The design on the sloping site produced a lower ground floor accommodating the teaching areas and a level above which contains the staff room, a number of small meeting rooms, the entrance foyer and reception area and the admin offices. Both areas of the building are linked by a central staircase and there is a long wide corridor leading to the classrooms which is used along its length for small learning support groups and activities. The building is constructed using a steel frame with a cavity wall envelope and pitched roofs with a natural slate covering. The lower ground single storey is provided with a north light roof covered with a zinc cladding with a canopy supported on cantilevered timber purlins.

The school is heated by a conventional gas condensing boiler and steel panel radiators with electric underfloor heating to the Hall. The classrooms have opening roof lights with rain sensors and each room is provided with a CO_2 sensor which uses a traffic light system which indicates with a red light when the levels are sufficiently high for the teaching staff to manually override the system and open a window. The school is ventilated by the use of a natural

ventilation system through the use of automated opening roof lights which can be programmed using the BMS to open at set levels of temperature or CO_2 levels.

The first stage of the BPCE is to carry out an assessment of the building using the standard format adopted by the local authority for providing a building condition survey and by reviewing the BMS and the O&M Manuals.

Figure 11: Site Plan

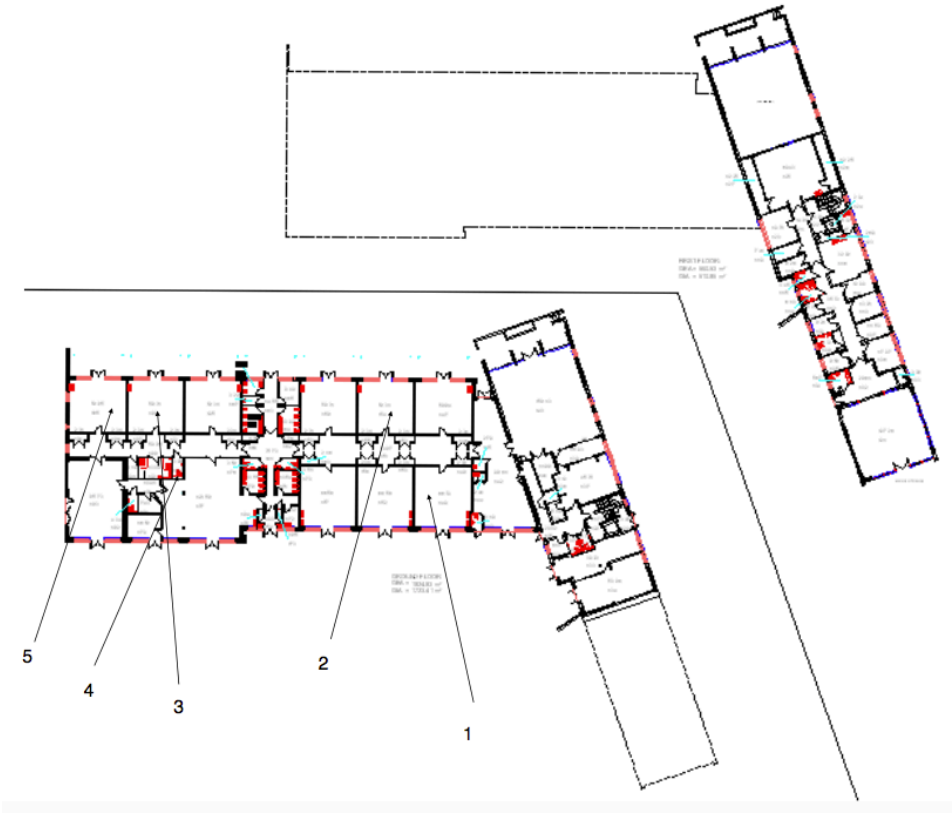


Figure 12: floor plans and location of the six dataloggers

7.3 Condition Survey

The Condition survey Chapter will contain the condition information from a condition survey carried out for the purpose of this exercise or from an existing condition information. This may involve a large amount of data held on a spreadsheet or as was the case with the modern school, a two year old building, very little other than future planned maintenance requirements. The chapter gives an explanation of the identification and of the prioritisation of building work and how it should be refined into the School Maintenance and Improvement Plan. The critical part of this exercise is to capture the most urgent priorities identified to be carried out in the short term. An example of the content of this chapter is shown below taken from the modern building report:-

2.0 Condition Survey

At the time of carrying out the condition survey the school buildings were under two years old and the completion of the defects period of the construction contract had recently expired. The condition of the property was unsurprisingly found to be very good and much of what was identified could be deemed to be planned cyclical maintenance issues. The building condition survey, and all future surveys, will be carried out using a conventional method of ratings as indicated in table 1. This contains an element description category, which identifies the nature of any defect, a condition rating, which grades the condition of the element and a priority grading which groups the maintenance work required into four timescales as shown. The format of the survey is to present the external condition information and then summarise the internal condition on a room by room basis (DfE, 2000).

Condition Category	F	H	L	
	Fabric	Health & Safety	Legal	
Condition Rating	A	B	C	D
	Good	Satisfactory	Poor	Bad
Condition priority	P1	P2	P3	P4
	Urgent	Essential	Desirable	Long Term
	immediate action	action within two years	within three to five years	over five years

table 7: condition survey categorisation (DfE, 2000)

The summary of the current building condition survey for the School is contained in Appendix 1. The condition data was collected in April 2016 and has been scheduled taking account of all anticipated work to be completed within the five year period from the time it was collected. This exercise is a vital starting point to consider the overall condition of the building structure, fabric and the mechanical and electrical building services installation. The approximate cost totals for the works required are identified and the P1-P4 prioritisation applied to each issue. All items that have a condition rating of D and a priority rating of P1 are deemed to require immediate action. This represent the highest priority work identified within the survey and the school would normally need to act on this straight away or to assess the risk and look to apply a budget to do

the work within the first year. All work that has a condition category of P2 will require attention within a two year period and those items which represent a greater risk to H&S or are required on legal grounds will be considered for year one. Items identified as being P3 or P4 will need to be reviewed and prioritised in accordance with the requirements of the school following and by a closer evaluation with the Premises Manager and the District Surveyor. This may be re-prioritised and considered along with the schools Development or improvement plans. The compilation of the 'School Maintenance and Improvement Plan' would be devised to capture all works required over a three year period and aligning the work identified to the schools available budget or identifying works that will need to be funded through any available bidding exercise. The input require to develop the condition survey into the SMIP is therefore quite a complex and involved process and raises the question as to whether the condition survey data should more accurately match the requirements of the school. It is the objective of the subsequent parts of this report to provide a more detailed appraisal of building performance and to prioritise these issues with the condition data and also to identify the consequences of any underperformance.

7.4 Energy Audit

The Energy Audit comprises a major part of the building performance assessment as it requires monthly data of energy use to be assessed against prevailing weather conditions, an appraisal of fabric losses, an assessment of the energy use form the school appliances, heating and ventilation. The following section illustrates how this exercise was carried out for the modern school and how it was presented in the BPCE report.

3.0 Energy Audit

The Energy Audit follows the Post Occupancy Evaluation (POE) assessment process (Gupta, 2006). The general procedure is as follows:-

1. *Evaluation of energy data from monthly Gas and Electric use in conjunction with local weather conditions (Degree Day analysis) and school occupation levels. This provides an assessment of the performance of the schools heating system and enables comparison with Benchmarks so as to identify any obvious energy use problems.*

2. *Assessment of fabric losses - appraisal of the performance of the building envelope and identifying possible improvements.*

3. *Assessment of the load from Appliances and electrical Equipment - computers (laptops/ desktops/tablets) Interactive teaching boards, printers, photocopiers, scanners, etc.*

4. *Lighting - Artificial and Natural light level measurements - Number, location and type of fittings in the building (low energy / energy use) - Effectiveness of the lighting installation (lighting levels associated with use).*

5. *HVAC - Heating, ventilation (user control) effectiveness, noise levels.*

The purpose of this audit of energy use is to understand how efficiently the school uses energy and to consider the possibilities of making savings by changing the use patterns that result in high energy use. Even if only small adjustments can be made then the school could receive long term benefits.

3.1 Evaluation of Energy Data

The energy use in a 'typical' primary school building is split into five main categories: space heating, hot water, lighting, other appliances and catering.

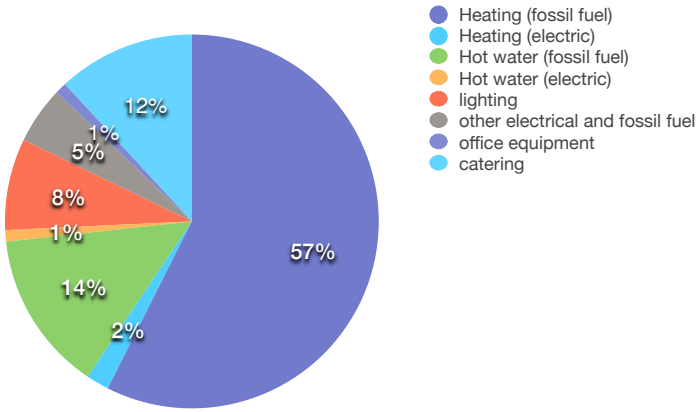
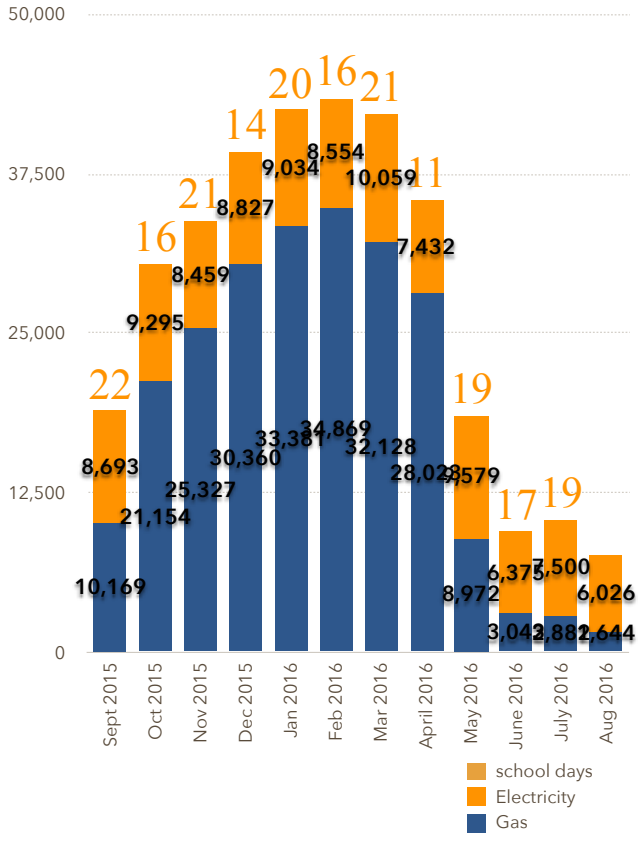


Figure 13: Energy use distribution for a typical primary school (Carbon Trust, 2012)

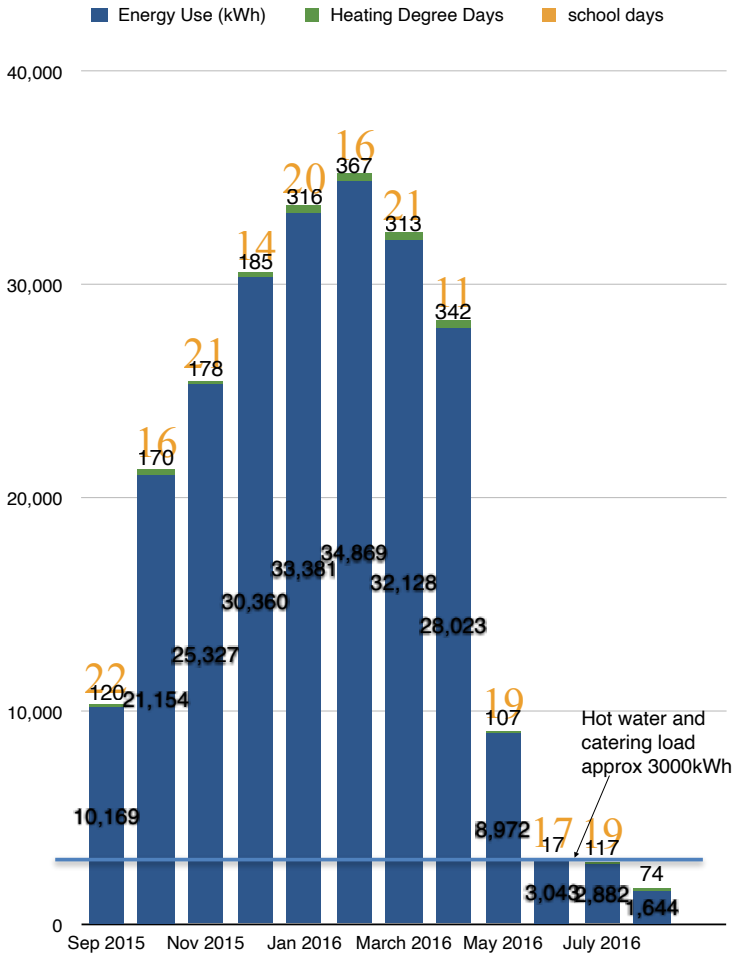
Figure 13 shows the proportion of energy that each category typically consumes. Clearly Heating and hot water are the main areas of consumption requiring approximately 74% of the

total energy used. The assessment of the gas and electricity use of the school begins with an understanding of the proportions of the load for each of the five categories and if any one of these looks out of balance with what it should be then it becomes the focus of further enquiry.



Month	Gas	Electricity	school days
Sept 2015	10,169	8,693	22
Oct 2015	21,154	9,295	16
Nov 2015	25,327	8,459	21
Dec 2015	30,360	8,827	14
Jan 2016	33,381	9,034	20
Feb 2016	34,869	8,554	16
Mar 2016	32,128	10,059	21
April 2016	28,023	7,432	11
May 2016	8,972	9,579	19
June 2016	3,043	6,375	17
July 2016	2,882	7,500	19
Aug 2016	1,644	6,026	0
Total	**231,952**	**99,833**	**196**

Figure 14: Total gas and electric energy consumption and the number of days each month that the school occupied.



Month	Energy Use (kWh)	Heating Degree Days	school days
Sep 2015	10,169	120	22
Oct 2015	21,154	170	16
Nov 2015	25,327	178	21
Dec 2015	30,360	185	14
Jan 2016	33,381	316	20
Feb 2016	34,869	367	16
March 2016	32,128	313	21
April 2016	28,023	342	11
May 2016	8,972	107	19
June 2016	3,043	17	17
July 2016	2,882	117	19
Aug 2016	1,644	74	0
Total	**231,952**	**2,306**	**196**

Figure 15 Gas consumption and heating degree days and school days per month

Finding reasons for excessive energy use measured in any area often leads to uncovering specific issues which can then be addressed and energy consumption improved. The exercise begins with the monthly energy consumption built up through all of the seasons of an entire year. The expected performance at particular times of the year then offers an opportunity to look for irregular usage.

Figure 14 shows total gas and electricity consumption per month in kWh and identifies the number of days each month that the school has been occupied for teaching. The gas consumption levels account for space heating, catering and hot water and increase during the winter months, as it is the primary fuel for space heating. The gas consumption declines in the summer months with August using 1644 kWh of gas, the school summer recess is from 24 July to 1 September and there are no days of occupation in August.

Figure 15 shows the distribution of gas use only and as the heating used much less from May, June is the only month in full occupation without heating. The hot water and catering line therefore shows the base load to be approx 3000 kWh. The remaining gas use each month is therefore used only for heating the building. This can be compared to the calculated number of degree days for each month. A degree day is a unit used to determine the heating requirements of buildings, representing a fall of one degree below a specified average outdoor temperature for one day. The base temperature used to calculate degree days in the UK is 15.5°C as it is assumed that at this temperature most UK buildings do not need supplementary heating. This is clearly a potentially inaccurate assumption and it should be emphasised that the degree day analysis is an approximate process of assessing the weather related energy consumption of buildings. It is however a very good indicator of how well the space heating is responding to external changes in temperature. To carry out the degree Day analysis this must be removed form the total gas consumption to leave the energy used just for space heating (figures in red in the table are an estimated split of the usage for July and August).

An important factor in the assessment is the number of days that the school is fully occupied for teaching in each month. Feb 2016 for example has the highest energy use and the highest number of degree days (367) although the occupancy was only 16 days. This strongly suggests that the school is being heated as if it was fully occupied ie that there is no programmed shut down for the holiday periods. This is also evident with December 2015 with 14 school days and with April 2016 with only 11 school days and yet the energy use is following the pattern of the degree days which are calling for heat when the temperature falls below 15.5 degrees centigrade. The gas consumption falls quite drastically in May as does the degree days to 107 although there is an interesting comparison to be made with the month of July 2016 where with only two less teaching days and 10 more degree days the gas use is only a third of that for May. July 2016 was a particularly cold month and this suggests that there should have been a

response from the boiler to provide more heat unless the drop in temperature occurred towards the end of the month when the school was unoccupied and on this occasion the boiler response did recognise the fact that the school was unoccupied and did not maintain occupied temperatures. Some further investigation is clearly therefore warranted to understand why the energy use has fluctuated in this manner.

Figure 16 shows the monthly electricity use and the cooling degree days i.e. the number of days where the external temperature rises above the base temperature and causing the building to need to be cooled to achieve its optimum temperature. This information is useful in assessing if any air conditioning is required or localised comfort cooling units. The overall requirement for the year is only 334 cooling degree days with 284 of these in June, July and August. The effect of the higher temperatures in the summer months has not resulted in greater electricity use which might be expected if additional fans or mobile air conditioning units were deployed in this period. Instead what the data reveals is that electricity use is a little erratic with an overall variation in the fully occupied months of between 6375 in June to 10059 in March and no clear correlation between number of days in occupancy and electricity use. There is also a very high electricity use for August when the school is unoccupied.

Figure 16 shows the electric consumption and the cooling degree day figures per month taken from the nearby Higham Weather station (www.degreedays.com).

If we compare the gas that is being used just for space heating together with the heating degree days i.e. days (actual gas use — building base load of approx 3000 kWh) a comparison of the heating with the degree days can be made using a regression analysis as shown in figure 6.The space heating linear regression represents the gas usage for heating (excluding the electric underfloor heating) as a function of the degree day demand. The best fit linear progression can be shown to be represented by the formula y = 108.33x + 3833.6. This is the predicted consumption and the line is an expression of how much energy the building can be expected to use for a given number of degree days. the slope is a measure of how much extra gas is consumed for an increase in degree days and the intercept is an indication of the non-weather

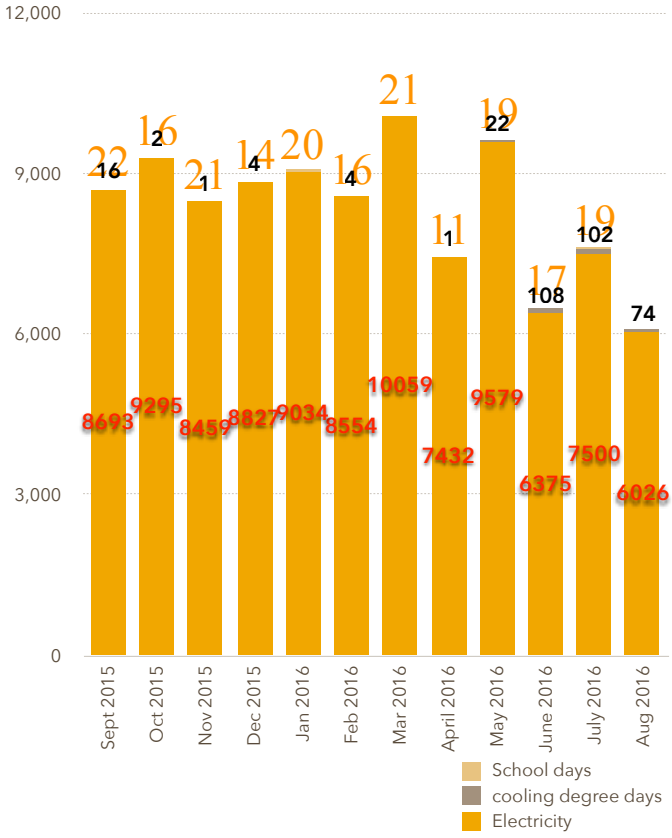
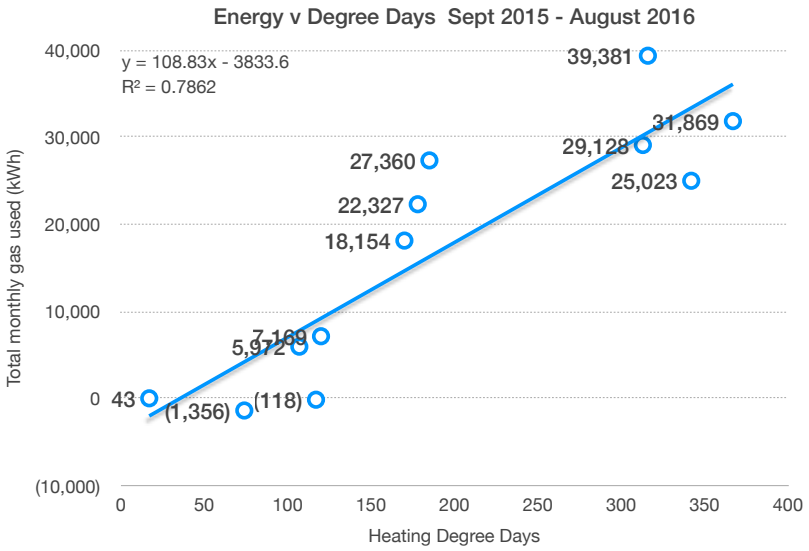


Figure 16 electricity use and cooling degree days

Month	Elec. kWh	cooling degree days	school days
Sept 2015	8,693	16	22
Oct 2015	9,295	2	16
Nov 2015	8,459	1	21
Dec 2015	8,827	4	14
Jan 2016	9,034	0	20
Feb 2016	8,554	4	16
Mar 2016	10,059	0	21
April 2016	7,432	1	11
May 2016	9,579	22	19
June 2016	6,375	108	17
July 2016	7,500	102	19
Aug 2016	6,026	74	0
Total	99,833	334	196

related energy use such as hot water and catering.The correction coefficient R^2 is a measure of how good the correlation is. The nearer the R^2 value is to 1, the closer the correlation. A good correlation between degree days and energy consumption indicates that the methodology is sound and that the heating system is working well (the "control" of the system is good). An R^2 value of 0.79 indicates a reasonably performing heating system. 0.9 or above is very good and an R^2 much below 0.7 is likely an indication that the heating control is either poor, or that the

analysis methodology needs to be improved e.g. irregular building occupancy that hasn't been



Month	HDD	kWh
Sept 2015	120	7169
Oct 2015	170	18154
Nov 2015	178	22327
Dec 2015	185	27360
Jan 2016	316	39381
Feb 2016	367	31869
Mar 2016	313	29128
Apr 2016	342	25023
May 2016	107	5972
June 2016	17	43
July 2016	117	-118
Aug 2016	74	-1356

Figure 17: Linear regression of monthly energy consumption against degree days showing line of best fit.

corrected for or heating metered together with other energy consumption that varies considerably throughout the year.

R^2 is an indication as to whether the system is responding in a consistent manner to the external temperatures. In this case the correlation is $R^2 = 0.79$ which suggests a reasonable correlation but temperature control is a problem in some areas of the building suggesting that the system is not responding to the external temperatures and there may be an issue with the internal temperature sensors conflicting with the external temperatures and further investigation of this is required.

The Control Chart enables a visual comparison to be made between actual energy consumption and the variation from the performance line each month. Figure 18 shows variations in the winter months where the predicted is lower than the actual from October to May and in the

summer months where the predicted is higher than the actual energy used. This suggests a situation where the use of the heating is more than would be expected in the winter and less in June, July, August and September 2016. This type of chart gives an opportunity for the facilities manager to look for corrective actions to bring these extremes into reasonable limits. The data suggests that the building is using an excessive amount of energy to heat the building from October to May 2016. this could be attributed to a number of reasons for example having the heating set too high or by opening doors and windows in the winter months or possibly a defect with the sensors calling for heat. further investigation is therefore required to understand why the building is widely varying from the predicted heating requirement. The summer performance suggests that the system is not calling for heat when the internal temperatures fall and this may explain the low energy use.

The Cumulative sum chart (CUSUM) shown in figure 19 is the accumulation of the differences between actual and predicted space heating energy from month to month. Where the graph rises the school is performing worse that the predicted case and where it falls it is seeing savings compared to the predicted. The results shown in the graph reiterate those in figure 7 in demonstrating that too much energy is being used in the winter period whilst the summer months show savings in energy use. The low occupancy levels in July and August account for this to some extent and uncontrolled heat gains may be responsible for the June figures. The explanation for the summer results can possibly be seen in staff complaints about low temperatures in the Admin areas where the heating seems to have not responded to the unusually high 117 degree days in July. A full investigation of the performance of the boiler and the sensors is required.

7.4.1 Fabric losses

A decision was made not to attempt to produce a calculation for the fabric losses as most primary schools building are a collection of building extensions that have taken place over a number of years which constitute a great variety of construction types which each complied with the building regulations in force at the time. To try to carry out a physical measurement of each type and assess its area and thermal resistance would be a very difficult, inaccurate and time consuming process.

Figure 18: Control Chart

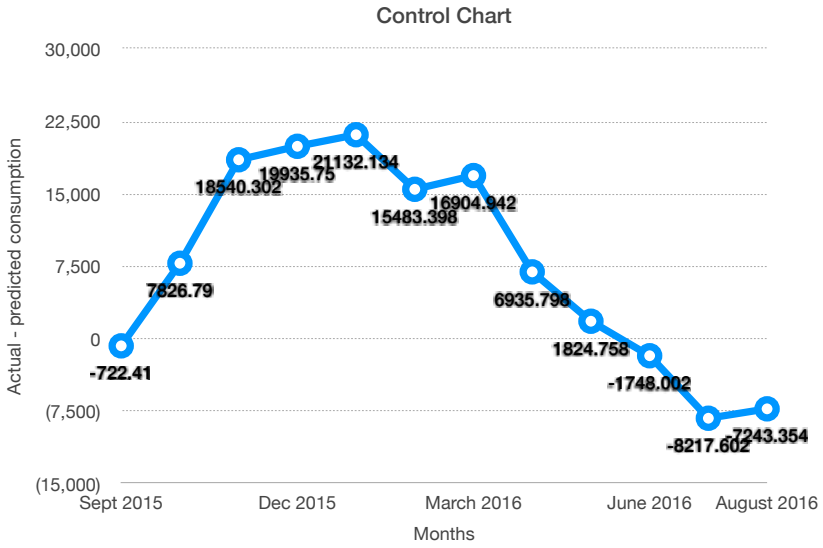
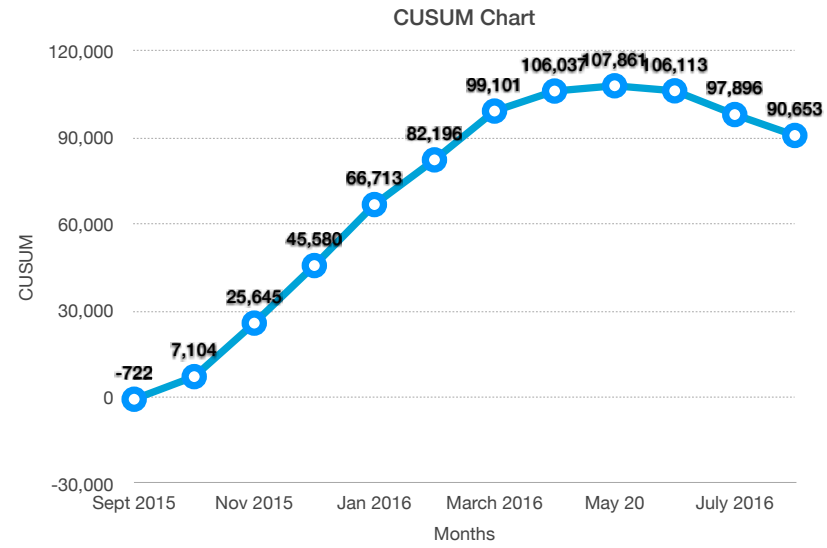


Figure 19: CUSUM Chart



The purpose of including this section is to assess the nature of the building envelope and to estimate the effect that it is likely to have on heat losses from the building. It was also

anticipated that comment would be included upon any aspect of the way in which the building is used and where there is unintended ventilation.

3.1 Fabric losses

The external envelope of the building is constructed of a cavity wall with a single skin of brickwork lining externally and containing 200mm of Rockwool insulation and 140mm blockwork internally with a 15mm plaster finish. The overall u-value for the walls is 0.17 W/m² K which is a very high performing envelope. The quality of construction is of a high standard with aluminium framed double glazed windows and doors having a U-value of 1.4W/m²/K. The main roof above the Admin area and the Hall is provided with an artificial slate covering and the classroom block has a zinc roofing finish, both are provided with a 200mm thick layer of rockwool insulation.

The ventilation of the school classrooms is provided by a natural stack effect created by the automatic opening and closing of inlet and outlet louvres in the glazing and on the roof dormers they are controlled by the BMS air quality sensors. The building was designed to achieve a Breeam 'Very Good' rating and an airtightness of 5 m³/hr/m² at 50pa this is a very good level of airtightness and will restrict drafts and uncontrolled ventilation.

The design incorporates provision for high levels of natural daylighting which should ensure that artificial lighting can be avoided for large parts of the day. Continuous roof lights at the ridge of classrooms provide optimum spread of light. In contrast to a traditional north light arrangement, which was intended to avoid sunlight, these ridge lights make use of the brightest light but by incorporating translucent gel so as to avoid heat gain. The configuration of the building is such that there is shade provided to the classrooms on both sides of the teaching wing of the building from the glazed roof canopy which extends the full length of the school on both the Southeast and Northwest elevations and providing a covered outdoor play area for every classroom. Direct sunlight only therefore enters the classrooms from the external windows in the early morning and in the late afternoon.

All of these provisions should cumulate to form a very energy efficient building with very low running costs and a well controlled comfortable environment using the array of internal sensors and the BMS.

7.4.2 Electrical power usage

This section was considered to be an important one taking account of the head teachers fears of increasing energy costs and the increasing use of electrically powered teaching aids in primary schools such as interactive plasma screens, laptops, i-pads etc. using information gathered for portable appliance testing the power of each item was assessed and an estimated ave daily use time applied to evaluating the likely energy use throughout the year. A similar exercise is carried out for lighting and then any other electrical use. The estimates can then be compared to the actual use per month and the accuracy of the exercise assessed by how close the calculated use is to the actual. Being aware of the use of electrical energy in this level of detail then allows the head teacher to know where to focus the attention in order to make savings.

3.2 Electrical power usage

The UK produces around 2% of global greenhouse gas emissions and is the 8th largest emitter in the world. Each year, the average person in the UK emits 9.8 tonnes of CO_2 ie double the global average. Primary schools in the UK use over 800 million kWh of energy and emit approx 1.6 million Tonnes of CO_2 per year which amounts to 5% of UK non-domestic emissions (CIBSE, 2012, Sustainable Development Commission 2011).

There are many ways in which schools can reduce their emissions and make savings against their energy costs but a fundamental part of the exercise is the measurement of the energy use not just overall but to identify those areas which are high consumption. The school can then identify effective targets for the reduction of energy costs.

In measuring the energy consumption of all of the schools appliances it is necessary to look at the power required to run an appliance and then the time it is used in the average school day. This is an approximate process but offers an indication as to what builds up to become a significant part of the schools energy costs as shown in table 8. The exercise helps the school to understand the implications of using their appliances in a particular way for example a PC monitor left on overnight can waste enough electricity to laser print over 500 pages (Energy Saving Trust). Mobile phone chargers, laptop docking stations and some desktop printers use energy regardless of whether they are charging or not because the voltage transformers on the

plug consume energy. This is known as electrical leakage. Only 5% of the power drawn by a phone charger is used to charge the phone. The other 95% is wasted when it is left plugged in.

Portable electric heaters can significantly interfere with the building's main heating system, as depending on locations, using an electric heater can send a message to the thermostat that the building is at temperature or too warm, meaning that the central heating gets turned off this makes the user of the heater and their colleagues feel even colder. Portable electric heaters can be up to three times as expensive as central heating. Nearly 50% of the CO_2 emissions produced by the UK come from heating and cooling in buildings. Turning the thermostat down 1°C saves 8% in heating costs, and significantly reduces CO_2 emissions.

The results of the appliance audit suggests that the school use approximately 53,355 kWh per year on all of its appliances and this amounts to 16% of the total energy use of the school. This is much greater than the 2012 average UK school which is 7% and is perhaps a reflection of the increased use of electrical devices in teaching. The lighting survey shows the energy use to be 4.4% of the total energy use and this is very much lower than the national average of 8% indicating the success of LED lighting.

Outdated Ultra Low Temperature freezers use two to four times as much energy as a normal freezer and poor maintenance of freezers can increase condensing temperature or reduce evaporating temperature by several degrees, resulting in an increase in energy use of up to 10%.

This exercise has highlighted the need for a specific focus on particular appliances and their energy use should be measured so as to establish if they are under performing and if they should be replaced or their use can be reduced. It has also highlighted the need for considering the best way for the school to use the appliances so as to achieve the most efficient energy use.

Table 8: Schedule of school appliances and approximate energy consumption

Location	Appliance	Watts	ave use time hours/day	power used kWh/day	all year use
3 Klee	PC x 3	450	2	0.9	
	OHP x 3	600	2	1.2	
Class 4	PC SCREEN x 5	500	2	1	
	PC x 5	750	2	1.5	
	OHP	300	2	0.6	
	sharpener	25	1	0.025	
	window vent	250	0.5	0.125	
7 Hutton	PC SCREEN x 4	400	2	0.8	
	PC x 4	600	2	1.2	
	LAPTOP X 2	200	2	0.4	
	CHARGER	25	1	0.025	
Art Store	GLUE GUN X 7	175	0.25	0.04375	
Bursar office	PC x 2	300	2	0.6	
	PC SCREEN X 2	200	2	0.4	
	CHARGER X 8	200	1	0.2	
	PRINTER	200	2	0.4	
	stereo	200	0.5	0.1	
Class 1	LAMINATOR	150	0.5	0.075	
	PC x 4	600	2	1.2	
	SCREEN	400	2	0.8	
	Interactive tv	250	2	0.5	
	visualizer	100	0.5	0.05	
	window vent	250	0.5	0.125	
	sharpener	40	0.5	0.02	
	FESTIVE LIGHTS X 2	400	0.1	0.04	
	LAPTOP X 3	300	2	0.6	
Class 2	PC x 4	600	2	1.2	
	PC SCREEN	100	2	0.2	
	sharpener	40	0.5	0.02	
	visualizer	100	0.5	0.05	
	CHARGER	25	1	0.025	
	FESTIVE LIGHTS	200	0.1	0.02	
	Interactive tv	250	2	0.5	
	light box	100	0.5	0.05	
	window vent	250	0.5	0.125	
Class 3	sharpener	40	0.5	0.02	
	PC x 3	450	2	0.9	
	PC SCREEN X 3	300	2	0.6	
	window vent	250	0.5	0.125	
	CHARGER X 2	50	1	0.05	
	FESTIVE LIGHTS	200	0.1	0.02	
Class 5	PC x 5	750	2	1.5	
	PC SCREEN x 6	600	2	1.2	

Location	Appliance	Watts	ave use time hours/day	power used kWh/day	all year use
	LAPTOP X 2	200	2	0.4	
	CHARGER X 2	50	1	0.05	
	LAMINATOR x 2	300	0.5	0.15	
	sharpener	40	0.5	0.02	
	FESTIVE LIGHTS	200	0.1	0.02	
Class 6	Interactive tv	250	2	0.5	
	PC x 5	750	2	1.5	
	PC SCREEN x 5	500	2	1	
	FESTIVE LIGHTS X 2	400	0.1	0.04	
	visualizer	100	0.5	0.05	
	CHARGER	25	1	0.025	
	sharpener	40	0.5	0.02	
	window vent	250	0.5	0.125	
Class 7	PC	150	2	0.3	
	PC SCREEN	100	2	0.2	
	CHARGER X 3	75	1	0.075	
	LAMP	100	0.5	0.05	
	Interactive tv	250	2	0.5	
	window vent	250	0.5	0.125	
Class 8	PC x 5	750	2	1.5	
	PC SCREEN x 5	500	2	1	
	Interactive tv	250	2	0.5	
	LAPTOP	100	2	0.2	
	visualizer	100	0.5	0.05	
	sharpener	40	1	0.04	
	window vent	250	0.5	0.125	
Class 9	PC x 5	750	2	1.5	
	PC SCREEN x 6	500	2	1	
	LAPTOP	100	2	0.2	
	CHARGER X 3	75	1	0.075	
	window vent	250	0.5	0.125	
CORRIDOR	tv x 2	500	1	0.5	
	LAPTOP	100	2	0.2	
	LAMP	100	1	0.1	
	BUFFER	3500	0.5	1.75	
	light box	100	1	0.1	
	PUMP	450	0.5	0.225	
	PC SCREEN	100	2	0.2	
	stereo	100	0.5	0.05	
Group Room	PC	150	2	0.3	
	PC SCREEN	100	2	0.2	
	Interactive tv	250	2	0.5	
	visualizer	100	1	0.1	
	CHARGER	25	1	0.025	
Hall	stereo x 2	200	0.5	0.1	

Location	Appliance	Watts	ave use time hours/day	power used kWh/day	all year use
	PC	150	2	0.3	
	PC SCREEN	100	2	0.2	
	Mixer deck	500	0.5	0.25	
	receiver x 2	200	0.5	0.1	
Head Teacher	PC	150	2	0.3	
	PC SCREEN	100	2	0.2	
	LAPTOP	100	2	0.2	
	PRINTER	200	2	0.4	
	CHARGER	25	1	0.025	
	LAMP	100	1	0.1	
ICT Store	PHOTOCOPIER	400	6	2.4	
IT Projects Mgr	PC x 2	300	2	0.6	
	PC SCREEN X 3	300	2	0.6	
	LAMP	100	1	0.1	
	CHARGER X 4	100	1	0.1	
	PHOTOCOPIER Utax 6505ci	750	4	3	
	stereo x 2	200	0.5	0.1	
	WATER boiler	2400	0.55	1.32	
	FRIDGE	250	24	6	
	EXTRACTOR FAN	1500	2	3	
Kitchen	FRIDGE x 3	750	24	18	
	MICROWAVE	850	0.5	0.425	
	KETTLE x 2	1500	0.25	0.375	
	cooker	2500	0.25	0.625	
	EXTRACTOR FAN	1500	2	3	
Lapsafe 1	LAPTOP X 16	1600	2	3.2	
	LAPSAFE CHARGER	200	4	0.8	
Lapsafe 2	LAPTOP X 11	1100	2	2.2	
	LAPSAFE CHARGER	200	4	0.8	
Lapsafe 3	LAPTOP X 14	1400	2	2.8	
	LAPSAFE CHARGER	200	4	0.8	
Lapsafe 4	LAPTOP X 15	1500	2	3	
	LAPSAFE CHARGER	200	4	0.8	
Library	PC x 4	600	2	1.2	
	PC SCREEN x 4	400	2	0.8	
	LAPTOP	100	2	0.2	
	LAMP	100	1	0.1	
	LAMINATOR	150	0.5	0.075	
	coomber	100	0.5	0.05	
	WATER boiler	2400	0.55	1.32	
	FRIDGE	250	24	6	
	MICROWAVE	850	0.5	0.425	
	CHARGER X 2	25	1	0.025	
LRC	tv	250	1	0.25	

Location	Appliance	Watts	ave use time hours/day	power used kWh/day	all year use
	PC	150	2	0.3	
	PC SCREEN X 2	200	2	0.4	
	PRINTER x 2	800	2	1.6	
	sewing machine x 8	800	0.25	0.2	
	FRIDGE	250	24	6	
	MIXER	300	0.25	0.075	
	WATER boiler	2400	0.55	1.32	
	EXTRACTOR FAN x 2	3000	2	6	
	TOASTER	1200	0.5	0.6	
	MICROWAVE	850	0.5	0.425	
	oven	2500	0.25	0.625	
	iron	1200	0.25	0.3	
	loop	150	0.25	0.0375	
	window vent	250	0.5	0.125	
Nursery	PC x 5	750	2	1.5	
	PC SCREEN	500	2	1	
	LAPTOP X 2	200	2	0.4	
	Interactive tv	250	2	0.5	
	LAMINATOR	150	0.5	0.075	
	sharpener	40	1	0.04	
	CHARGER	25	1	0.025	
	light box	100	1	0.1	
	visualizer	100	1	0.1	
	FESTIVE LIGHTS X 2	400	0.1	0.04	
Plant Room	VACUUM	1500	0.5	0.75	
	VACUUM	1500	0.5	0.75	
	BUFFER	3500	0.5	1.75	
	CHARGER	25	1	0.025	
PPA Room	PC x 3	450	3	1.35	
	PC SCREEN	100	3	0.3	
	PRINTER	200	2	0.4	
Reprographics	PHOTOCOPIER Utax 6505ci	1480	4	5.92	
	SHREADER	100	0.25	0.025	
	LAMINATOR x 2	300	0.25	0.075	
	binder x 2	500	0.25	0.125	
SEN Maths	PC x 2	300	2	0.6	
	PC SCREEN X 2	200	2	0.4	
	HAND DRIER	1800	3	5.4	
	stereo	100	0.5	0.05	
	CHARGER x 2	50	1	0.05	
	FESTIVE LIGHTS	200	0.1	0.02	
Server Room	CHARGER X 22	550	1	0.55	
	tv x 7	1750	0.5	0.875	
	heater	1500	1	1.5	

Location	Appliance	Watts	ave use time hours/day	power used kWh/day	all year use
	DESK FAN	100	1	0.1	
	visualizer	100	1	0.1	
	cctv	200	24	4.8	
	cctv monitor	100	24	2.4	
	LAPTOP	100	2	0.2	
	Comfort cooling unit	750	24		6570
SMT Office	PC	150	2	0.3	
	PC SCREEN	100	2	0.2	
Staffroom	tv	100	0.5	0.05	
	FESTIVE LIGHTS X 2	400	0.1	0.04	
	FRIDGE x 2	500	24		4380
	MICROWAVE	850	0.5	0.425	
	WATER boiler	2400	0.55	1.32	
	DISHWASHER	250	0.5	0.125	
	EXTRACTOR FAN	1200	2	2.4	
	window vent	250	0.5	0.125	
Store	VACUUM	1500	0.5	0.75	
	VACUUM	1500	0.5	0.75	
	VACUUM	1500	0.5	0.75	
	CHARGER	25	1	0.025	
	FESTIVE LIGHTS	200	0.1	0.02	
	VACUUM	1500	0.5	0.75	
	VACUUM	1500	0.5	0.75	
Studio	stereo x 3	300	0.5	0.15	
	CHARGER	25	1	0.025	
	receiver	100	0.1	0.01	
	OHP	300	1	0.3	
	PA system	250	0.5	0.125	
Teacher Entry	PC	150	3	0.45	
	PC SCREEN	100	3	0.3	
toilets	HAND DRIER X 10	18000	3	54	
				0	
			AVE DAILY USE	216.35625	10950
			ANNUAL USE	42405.825	
			TOTAL ANNUAL USE	53355.825	
KITCHEN	CHARGER x 2	50	1	0.05	
	FRIDGE x 2	700	24		6132
	FREEZER X 2	700	24		6132
	TOASTER	1200	1.5	1.8	
	WATER HEATER	2400	4	9.6	
	KETTLE x 2	2400	1	2.4	
	DESK FAN	150	0.5	0.075	
	oven	2500	1	2.5	
	HOT CUPBOARD	2400	2	4.8	

Location	Appliance	Watts	ave use time hours/day	power used kWh/day	all year use
	MIXER x 2	600	0.25	0.15	
	EXTRACTOR FAN	1500	2	3	
	SHUTTER x 3	4500	0.25	1.125	
	INSECTOCUTER	150	24		1314
	stereo	100	2	0.2	
	HAND DRIER X 2	3600	0.5	1.8	
	window vent	250	0.5	0.125	
			AVE DAILY USE	27.625	13578
			ANNUAL USE	5414.5	
			TOTAL ANNUAL USE	18992.5	

3.3 Lighting

The building was designed to make as much use as possible of natural daylight with large and very tall windows in each classroom and the orientation of the building is such that there are no classroom windows facing due south and glare and solar gains seems to have been largely excluded by the careful design of the building. Blackout blinds are used to control some glare in classrooms and whilst this results in the lights remaining on for a period during the day most areas also have some borrowed light from other internal areas or roof lights limiting the need for artificial lighting.

The condition survey identified a small number of defective light fittings with the school lighting system providing excellent and controllable lighting levels to all teaching areas, circulation spaces and support areas. The fittings are of a good standard and efficiency and the classrooms have been provided with LED suspended light fittings which are dimmable and provide a very good standard having lighting level of up to 400 lux at table height towards the centre of the room when all of the lights are full on.

Defective light fittings which result in lower or unbalanced lighting levels and flickering light have been identified as detrimental to occupiers well being causing headaches and nausea and possibly epileptic seizures. When functioning correctly, mains-powered fluorescent lighting has a flicker rate typically 100 Hz or 120 Hz which is unlikely to cause any problems. However, high-efficiency LED lighting operates at much higher frequencies which would not be perceivable by the human eye, though defective lights of any type can cause problems and must therefore be

identified and replaced in order to avoid any ill effects.

A comprehensive audit of the artificial light fittings throughout the school was carried out after the hours of darkness to measure the artificial lighting load. The different areas can be seen outlined in table 9. The spreadsheet was generated by recording the various light fittings in each room and the total wattage for the space with the total areas for each and the installed load in W/m² was calculated so that a comparison could be made against suitable benchmarks. An average measure of the lighting levels from the artificial lighting only was made using a light meter and this was also recorded with the load to indicate the performance of the lighting in the space. Where lighting levels were adjustable using dimmers the measure was made at the level that was used for the last teaching session of the day. It was assumed that this was the teachers chosen setting and the one most commonly adopted.

The installed internal lighting load of the school was found to be a very low 7.4 W/m² which exceeds the upper region of the expected range of 10-20 W/m² (CIBSE, 2004). The school has been provided with the most up to date lighting all of which is LED highly economical and high performing. The range of loads recorded from 4.7W/m² to 16W/m² for small storage areas. The total lighting load for the building was calculated on the basis of there being 196 teaching days per year and an approximate use of the lighting for 5 hours per day ie 16.95kW x 5 x 196 = 16,611kWh/yr this equates to 4.4% of the overall energy load. However the large windows and roof lights which are provided to every classroom may result in the lighting being used for less than 5 hours per day. The use of low energy consuming LED fittings throughout the school has resulted in a lower than average use despite the size of the school which is reflected in the number of pupils on roll which is 343 compared with the average primary school size of 275 pupils (Schools, pupils and their characteristics: January 2016 SFR 20/2016 DfE, 28 June 2016). The building is also larger than the average Primary school with a gross floor area of over 2000m².

Table 9: Schedule of lighting

Room	Area	Installed load	loading	ave Lux level
	m^2	Watts	W/m^2	
Main Entrance Foyer	107	560	5.2	200
Reception Lobby	29	220	7.6	250
disabled toilet 104	6	38	6.3	180
Reprographics Room 105	9	54	6.0	280
School Office 106	18	134	7.4	300
Room 107	12	80	6.7	320
Room 108	6	38	6.3	240
Room 109	8	80	10.0	250
Bursars Office 110	14	136	9.7	295
Project Mgr Office	11	80	7.3	290
LRC Rm 116	33	330	10.0	300
Room 113	5	50	10.0	210
Corridor 112	36	300	8.3	150
toilet rm 114	6	38	6.3	200
toilet Rm 115	3	38	12.7	220
Copier room 118	8	80	10.0	240
Head teacher Office	20	160	8.0	320
Staff Room	70	336	4.8	280
Staff room cupboards x2	25	160	6.4	260
staircase	34	456	13.4	230
Site supervisor Room	6	80	13.3	275
toilet 130	4	38	9.5	180
toilet 131	4	38	9.5	180
Corridor 135	29	320	11.0	200
Hall	158	1344	8.5	295
Hall equip store	12	80	6.7	190
Servery	16	104	6.5	280
Kitchen	45	440	9.8	445
Kitchen store	5	40	8.0	190
cleaners store	3	40	13.3	220
Library	60	470	7.8	325
SEN area	25	315	12.6	300
Library kit & store	5	80	16.0	240
Main corridor(151 and 188)	134	820	6.1	270
Central crossing corridor (163, 161 and 174)	55	360	6.5	270
Classroom 1 (149)	67	448	6.7	385
Classroom 2 (152)	67	448	6.7	420
Classroom 3 (157)	67	448	6.7	420
Classroom 4 (147)	59	448	7.6	320
Classroom 5 (154)	58	448	7.7	410
Classroom 6 (158)	58	448	7.7	390

Classroom 7 (195)	58	448	7.7	400
Classroom 8 (189)	58	448	7.7	400
Classroom 9 (185)	59	448	7.6	380
Nursery (177)	124	676	5.5	350
Nursery store Room (179)	17	80	4.7	240
Studio	86	520	6.0	350
Staff Work Room (166)	6	80	13.3	370
Head's Office (165)	20	160	8.0	300
Staff toilet (167)	3	40	13.3	250
toilet (168)	11	114	10.4	350
toilet (164)	11	114	10.4	350
toilet (176)	4	40	10.0	260
toilet (170)	4	40	10.0	270
toilet (178)	11	114	10.4	375
toilet (171)	11	114	10.4	270
Disabled toilet (192)	13	152	11.7	270
Studio toilet (182)	4	40	10.0	250
Cleaners room (172)	6	40	6.7	160
Store room (181)	7	40	5.7	190
Store room (191)	4	40	10.0	185
Store room (193)	4	40	10.0	185
Boiler Room 133	40	252	6.3	120
Boiler Room 134	50	224	4.5	110
internal lighting TOTAL	2008	14889	7.4	
External bulkhead lights		420		
External carpark lighting		1670		
TOTAL including external lighting		16979		

3.4 HVAC

The psychological effect of removing an occupiers ability to open windows when a room feels stuffy is such that even if there is only a slight sense of environmental discomfort this will be exaggerated by their inability to affect it in a positive way themselves (Bordass, 2005). The school has therefore been provided with a system of openable windows and the motor driven roof lights to allow full control of the ventilation to the classrooms.

There is no air conditioning within the school apart from a small comfort cooling unit located in the comms room which simply neutralises the heat gains from the school server unit. The school has been provided with a NaturalVentilation system with each of the classrooms having an

openable roof light and a warning system which identifies high levels of CO_2 and calls for the roof light to be opened manually. The BMS enables the system to operate automatically and be set at CO_2 level activation or temperature level activation. At the time of the inspection the automatic activation was set to 21°C although each classroom could enter its own settings, although the staff were generally unaware of how to change this.

The main disadvantages of a natural ventilation system is that in the winter or times of inclement weather the building users are reluctant to open windows for fear of rapid heat losses or rain being blown into the building. They are then likely to become tolerant of the build-up of CO2 levels and poor air quality. In the summer months if there are high ambient air temperatures and low levels of air movement then some overheating may result and on occasions when strong winds are prevalent there can be levels of air movement which are excessive and cause doors and windows to slam shut or paper and posters etc to be blown around.

Table 10 shows the Govt guidance for heating of teaching areas and in order to conserve energy these should not be exceeded. Outdoor play is an important part of the curriculum for primary school children and enabling frequent access from internal areas to the outdoor play areas can result in significant heat losses in the winter months when the external temperatures are relatively much lower. Another possible reason for the high energy use in the winter months could be the frequent re-heating of the classrooms following periods of outdoor play when the external doors are frequently opening and closing.

Temperature - °C	activity
18	Normal Teaching
15	circulation spaces and high level activity areas eg Gym, Hall etc
21	Special Needs schools, low activity levels or areas for very young children

Table 10: Recommended temperatures for schools, by activity (DfES Guidance 0029/2000 Standards for School Premises)

3.5 Energy Audit Conclusions

The building does not perform well in terms of its winter gas consumption possibly because of the failure of the heating system sensors or excessive heat losses from classrooms which have no means of containing heat during the outdoor play sessions. It may also be the case that the

heating being provided to the building in winter exceeds the recommendations outlined in table 10.

It has been shown that internal lighting consumes 14,602kWh/yr and external 1,229kWh of electricity, the kitchen is estimated to use 18,993kWh/yr and the electrical appliances within the school account for 53,355kWh/yr. The underfloor heating installed in the hall which based upon a 200W/m2 system when used for 2 hrs per day will result in approx 8,000kWh/yr if it is used for 125 days per year. The 630kg, 8 person passenger lift would be expected to use approx 1,500kWh/yr based upon light use. The three automated gates which are in daily use will consume approx 1.2kWh/day so approx 225kWh/yr. The school generates electricity from a 2.16kWp array of photovoltaics which produce approximately 1800kWh/yr. Taking this into account the total identified use amounts to 96,098kWh/yr and the overall electrical energy consumption for the school in 2016 is 99,833kWh/yr. There is therefore a difference of 3,735kWh/yr which is a very small amount of energy considering it should include for things like; cctv, Fire alarm and intruder alarm systems, energy used for heating and lighting of outbuildings and the powering of any water features. It will also include the electrical energy used in association with the heating system ie pumps, control panels etc which may amount to an energy use in excess of this difference.

It is clear that many approximations have been used in the electricity use calculations and a further check of the details of how the appliances are used on a daily basis would result in greater accuracy. A closer examination of how electricity is used by the school may account for the difference between the predicted and actual use.

7.5 Environmental Assessment

The third part of the BPCE Report is the Environmental Assessment, this provides an indication as to how well the building is performing with regard to its overall environmental impact and measures the internal environmental conditions. A number of environmental issues are evaluated including overall CO_2 emissions, recycling, water efficiency and these are benchmarked against typical usage and guideline performance. The internal environmental performance is measured using the dataloggers to record CO_2 concentration, Relative Humidity and Temperature.

The following section is taken from the Modern school assessment and indicated the process followed and the collection and how the data is presented.

4.0 Environmental assessment

The Environmental report will look at the environmental impact of the school in some detail starting with the CO_2 emissions and also considering the recycling and waste management, water usage and the internal environmental conditions. This section will appraise the quality of the internal environment being generated from the energy use figures with particular emphasis on the teaching areas. The monitoring of the CO_2 concentrations within the teaching areas provides an indication of how well ventilated the spaces are and if there is any need to improve them. The monitoring will also cover temperature and this provides an indication of the control of temperature in the occupied classrooms to see if there are any adjustments required. The relative humidity measurements provide an indication of moisture levels in the air and to check that they are generally in the range of approx. 30% to too 70%. higher levels are an indication of excessive moisture evaporating into the space and may require the source of the moisture to be removed.

4.1 Building CO_2 Emissions

The DEC produced for the school in September 2015 identified the schools predicted CO_2 emissions as being 13.8 $kgCO_2/m^2$. This was established from using IES Virtual Environment software and generated from the design information. However, using the actual gas use for the building of 231,952kWh/yr and applying the conversion factor of 0.184KgCo2e/kWh the emissions from gas use are 42,679Kg CO_2 e. The electricity use of 99,833kWh/yr converts to a total of 41,131Kg CO_2 e when applying a conversion factor of 0.412Kg CO_2 e/kWh. The

combined total is 83,810Kg CO_2 e which when divided by the usable area of 2233m^2 produces an overall emissions of 37.5Kg CO_2 e/m^2.

This is considerably more than the predicted figure of 13.8 kgCO_2/m^2 and suggests that the building energy use is some way from matching its design intentions. These two areas of energy consumption put the schools CO_2 emissions at 83.8 tonnes per year and the water usage of 954m^3 per yr will add approx another 754kg to this using the conversion factor of 0.79g CO_2 e/ litre (ococarbon.com , 2016). This figure of 84.55T is based upon actual consumption is still considerably less than what the average primary school would produce using the 50.5Kg CO_2/ m^2 benchmark for schools and seasonal public buildings (CIBSE, 2008).

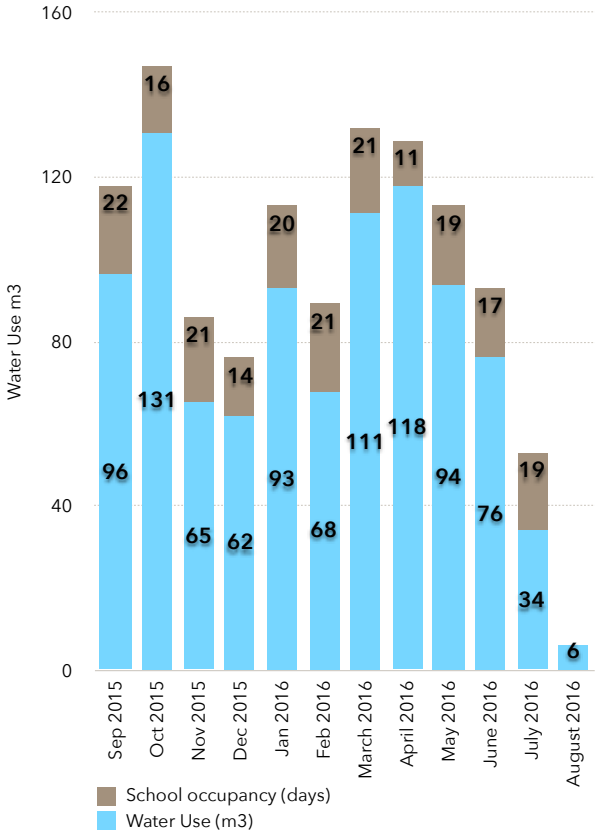
The next section of the report involves an assessment of what the school is achieving with regard to its waste management procedures and if it is part of any government scheme or initiative such as the Ecoschools programme. The level of detail is dependent upon the extent to which the school has decided to be involved and in some cases effort could be made to quantify the amount of waste being recycled. In this school the involvement was relatively light and this is reflected in the comments below.

4.2 Recycling and Waste management

There are measures in place to encourage students and staff to reduce or recycle their waste. There are currently containers available for plastic waste, and for cardboard/paper recycling . Each class has designated bins and staff and children are encouraged to use them. The school also collects used batteries in a tall slender transparent tube receptacle in the entrance foyer which provides an indication of the filling up of the tube over time. The batteries are then collected for appropriate disposal. There are no existing metal or glass-recycling facilities at the school.

4.3 Water usage

It was recorded that 954m3 of water was used in the school in 2015/16 which amounts to 954,000 litres. With an approximate occupancy of 343 students this equates to14.6l/pupil/day which is considerably lower than the good practice benchmark of 20l/pupil/day.



Month	Water Use (m^3)	School occupancy (days)
Sep 2015	96	22
Oct 2015	131	16
Nov 2015	65	21
Dec 2015	62	14
Jan 2016	93	20
Feb 2016	68	16
March 2016	111	21
April 2016	118	11
May 2016	94	19
June 2016	76	17
July 2016	34	19
August 2016	6	0
Total	**954**	**196**

Figure 20: Water use Sept 2015 to Aug 2016

On average primary schools, without a pool, use 5.2m^3/pupil/year and those in the best performing 25% use 3m^3/pupil/year which puts the school into the best performing category with 2.78m^3/pupil/yr (Hassell, 2015).All of the sanitary fittings within the school are water saving

appliances from the push activated click taps to the water efficient cisterns of the wcs. The combined effect of this is has been to reduce the overall water consumption. However there is no surface water recycling and the school has not been designed with any form of sustainable drainage systems.

A concern with the water use is the highly inconsistent use per month throughout the year, October , March and April are very high using 360m^3 with only 48 fully occupied school days and November, December and February are very low by comparison using only 195m^3 in 56 fully occupied school days. July also has a very low use of only 34m^3 and yet there are 19 school days in this month. The wide variation in these figures are difficult to explain when compared with the schools occupancy levels. Leakages from the system would tend to be a constant presence unless they were occurring intermittently which seems unlikely. The water use for October 2015 was 131m^3 which represents the highest use month and yet the school was only in occupation for 16 days. The school was in its first year of occupancy in 2015/16 and this might explain the Sept and October high readings although future monitoring of the water use figures should be carried out in order to see if this trend continues or whether it settles down to a more regular level

4.4 Internal Environmental conditions

One of the main reason for measuring the internal environmental conditions of a building is to assess the comfort within the occupied spaces, and to help evaluate how the teaching conditions support the learning activities within them. This exercise was completed with the use of Extech SD800 data logging meters to capture readings for the CO_2 concentration, the relative humidity and the temperature every minute for a period of three to four weeks simultaneously in six classrooms. Whilst this short time interval led to a considerable amount of data being captured it was considered to be important to capture the precise moment when conditions changed so that this could be related to the classroom activity. The monitoring took place during the winter term on 6 November up to 4 December 2015 in the six locations shown in figure 12.

The attention levels of children of primary school age has been shown to drop by as much as 5% in environments with CO_2 concentrations of the order of 2500ppm (Coley and Greaves, 2004). CO_2 is an indicator of indoor air quality and exhaled air is usually the principal source of CO_2 in schools the levels inside classrooms are affected by a number of factors including:

- *the number of occupants in the room;*
- *the activity levels of occupants;*
- *the amount of time occupants spend in the room; and*
- *the ventilation rate. (DfE, 2016)*

Any assessment process needs to take these factors into account and the principal issue is the number of persons present in the classroom and the volume of the space. The time spent in primary school classrooms by the children are roughly similar across different schools although the activity levels can vary significantly. However the purpose of the exercise is to identify if there is a problem with CO_2 build up in the specific classroom and not to benchmark the premises against other schools.

Airborne fungi and dust mites can also be a problem as in moist warm conditions they can thrive and their droppings are known to cause allergic reactions in some people. Mycotoxins, or fungal toxins, are biomolecules produced by fungi, some of which are toxic to animals and human beings. Although quite rare toxic moulds have been identified as a serious health risk to occupants and so for this reason the conditions for all mould growth should be avoided.

Odour is an indicator of poor air quality and it is emitted from people and from various materials that may be found in school buildings such as paints, cleaning materials, adhesives and building products etc. Historically the level of outdoor air provided to a classroom was specified to avoid significant odour as perceived by persons entering the room (DfE, 2016). Occupants already in a room will generally not be aware of odour, as the olfactory sense rapidly adjusts to any medium to long term exposure to odour. Odours can therefore build up to unpleasant levels and a sufficient outdoor air supply is needed to dilute and remove them.

Asbestos and asbestos-containing materials (ACMs) are commonly found in schools built or refurbished before 1985, although some asbestos containing materials continued to be used up until 1999. This suggests that asbestos fibres could be present in the air and therefore a significant health risk in a very high percentage of schools in the UK. If the materials are disturbed or become damaged, asbestos fibres may be released into the air and present a risk if inhaled. Some damaged ACMs can be made safe by repairing them and sealing or enclosing

them to prevent further damage. Where ACMs cannot be easily repaired and protected, they should be removed (HSE, 2000). Asbestos can only be identified in laboratory conditions and so sampling is necessary to carry out tests. It is accepted that the need for air testing is not necessary unless major disruption has occurred to asbestos containing materials. for this reason it is not considered necessary to routinely test air for asbestos content.

On analysing the data collected from the teaching areas it was found that in all cases the CO_2 levels followed the same pattern over the working week, steadily increasing up to each break-time during the day and then receding whenever the classrooms were unoccupied. At lunchtime the levels reduced to the lowest levels but never to the low at the start of the day, hence at the end of the teaching day the highest levels of CO_2 concentration were recorded. At the end of the school day the levels fall sharply back to the CO_2 concentration that would be associated with the empty classroom i.e. external CO_2 levels of circa 4-500ppm proving the teaching areas to be well ventilated when the doors are open. Figure 21 indicates the CO_2 concentration in classroom 1 where CO_2 levels of 2837ppm were recorded in the period after lunchtime on Thurs 26 Nov. The rate at which the CO_2 levels return to the ambient levels of circa 450ppm at the end of the day give an indication of the air tightness of the classroom. The class empties at circa 3.00pm and the levels of CO_2 rise again indicating some further activity after 3pm and the concentration are not reduced to 450ppm until around midnight some eight and a half hours later. This is also borne out by the steep incline of the graphs form about 8.45am when the classroom doors are closed and teaching begins, by 10.00am the CO_2 levels are above 1800ppm for three days of the week. On Mon, Tues and Wed the CO_2 concentration rises above 2000ppm in either the middle or final session of the day and on Thursday and Friday there appears to be quite long final teaching sessions which cause the CO_2 to rise above 2500ppm on Thursday and up to the highest recorded level of the week of 2837 ppm on Friday.

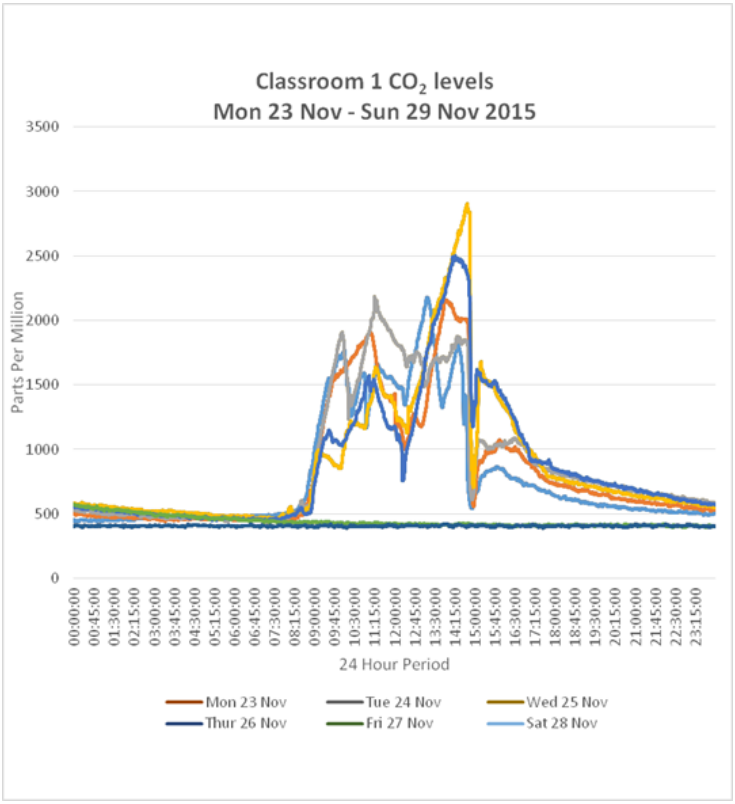


Figure 21: CO_2 levels in classroom 1 from 23 to 29 Nov 2016

Classroom 1 of Whitefield School has opening windows and a roof light vent which can be opened manually or set to open automatically when the temperature reaches at specific point or when the CO_2 concentration rises to a given level. There is a level of control of the ventilation provided from the large external doors to each classroom and the door out on to the main corridor.

Figure 22 shows the recorded levels of temperature and relative humidity over the week commencing 23 Nov 2015. The RH levels are contained within a healthy band of between 33% and 58% although there is a gradual increase in RH as the week progresses with temperatures never falling below 16.8 °C and beginning to rise on Monday 23 Nov at approx 1.45am. A

temperature of approximately 23°C is reached by the heating system in Classroom 1 by 5.30am and this is a high temperature and provided very early in the morning long before the school is fully occupied. This could be an explanation as to why the school is using so much energy in the winter months.

Moisture is generated through occupant activities, for example breathing and exhaling moisture and high humidity in spaces such as classrooms can lead to moisture condensing on cold surfaces resulting in fabric decay and mould growth.

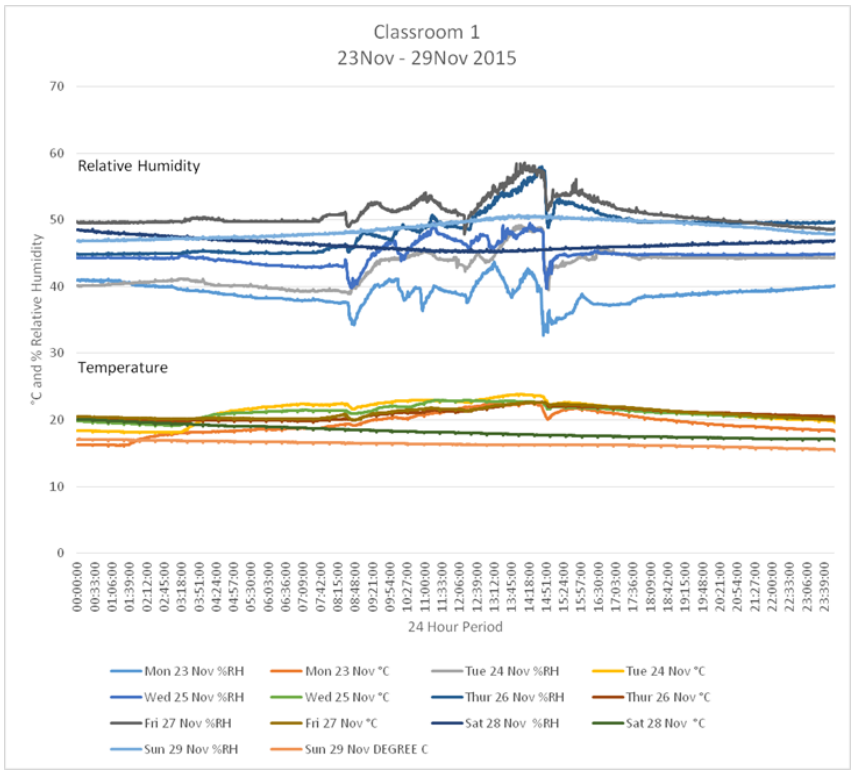


Figure 22: Relative Humidity and temperature in Classroom 1 from 23 to 29 Nov 2015.

The school is not vulnerable to condensation as a result of having a well insulated cavity wall and large areas of high performing double glazing in the envelope combined with this is the

good temperature levels throughout the school. Figure 11 shows the relationship between RH and temperature with falling temperatures increasing the humidity. The opposite can be seen as humidity levels fall during the warmest period of the day. The fluctuation of the humidity levels is related to the high occupancy period when the classroom is fully occupied there are variations in humidity levels which coincide with the teaching periods of the day and the humidity is being affected by the changing levels of ventilation.

The CO_2 levels recorded in Classroom 5 are shown in figure 23. Here we see the same characteristics as Classroom 1 with the steeply rising levels of CO_2 at the start of the first teaching period and a steep fall off at about 3pm. On Monday 23 Nov there is a very short mid morning break and then a long teaching period to lunch where all of the doors and windows are closed where the CO_2 levels rise to above 3000ppm at about 12 noon.

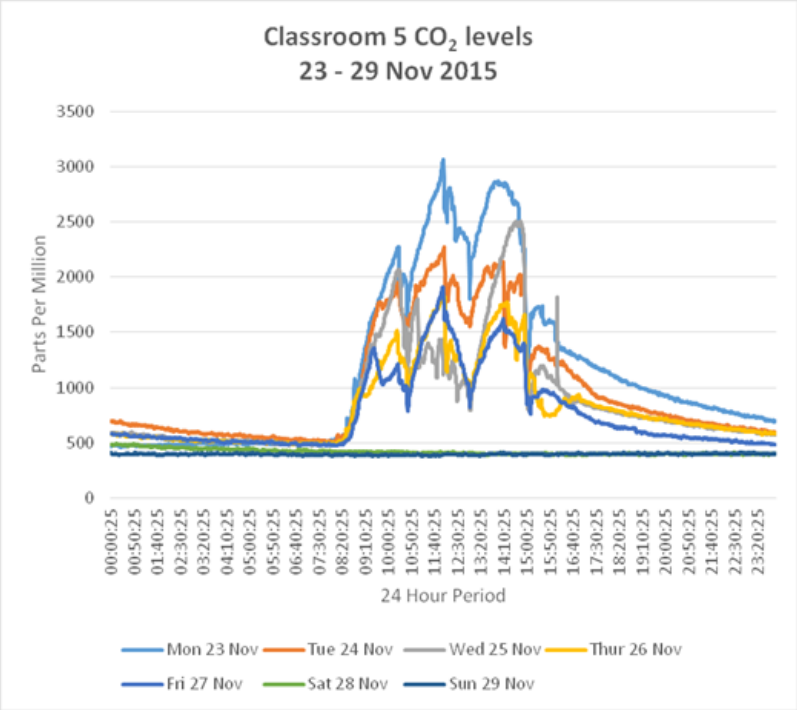


Figure 23: CO_2 levels in Classroom 5 from 23 to 29 Nov 2015

The three peaks of activity are clearly reflected in the CO_2 levels shown in figure 12 for classroom 5 with Monday recording the highest levels above the Tuesday mid session and the final session of Wednesday which rises to 2500ppm. The end of the school day at approx 3.00pm is again shown by the very marked drop in CO_2 and whilst there is a little further activity after this by around 4pm the CO_2 levels start to recede again. The starting point for the decline is about 1400ppm on Monday down to about 1000ppm on Friday and it takes almost 15 hours from 4pm to 7am for the levels to reach 450-500ppm.

The levels of relative humidity for classroom 5 are shown graphically in figure 24. The levels generally mirror the heating with the arrangement that RH rises as the temperature falls and vice versa. The large diversity in the RH data outside of occupied classroom time is entirely due to the variation in temperature produced by the heating system. During the teaching periods the humidity is enhanced by the occupiers and by the introduction of improved ventilation often for short periods of time. This is not an uncommon phenomena for November in East Lancashire where there are daytime high temperatures of 8-9 °C and lows of 3-4 °C. This level of external temperature would result in significant heat losses even if windows are opened for short periods.

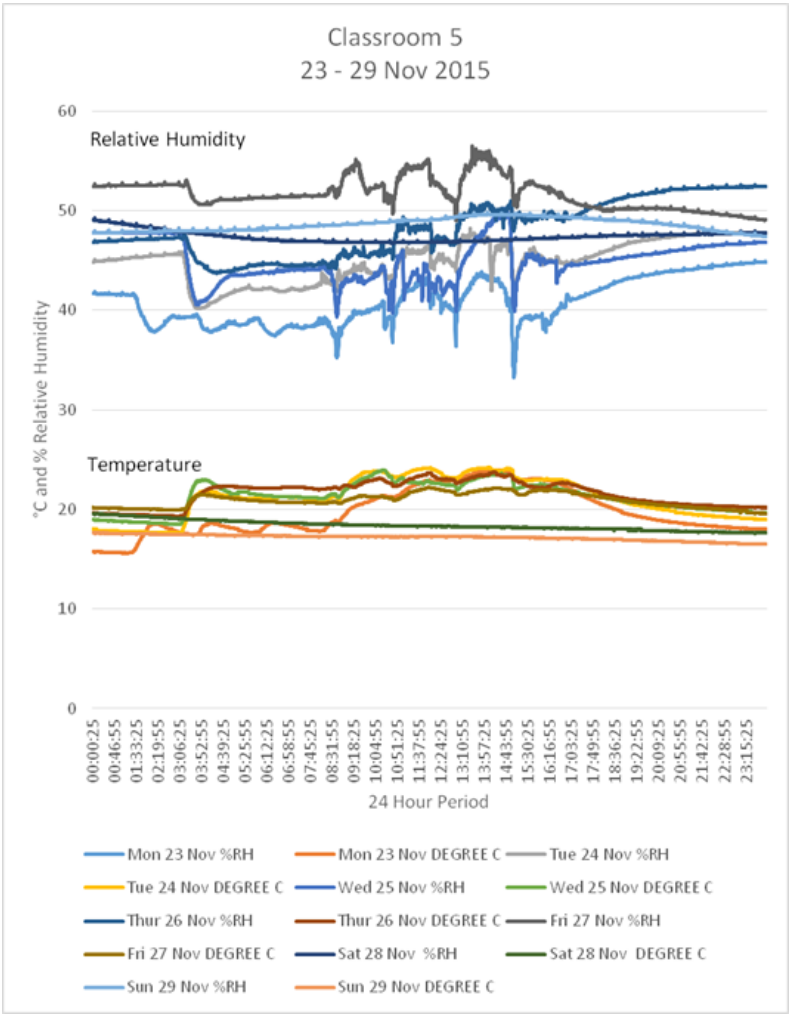


Figure 24: Relative Humidity and temperature in Classroom 5 from 23 to 29 Nov 2015

The temperature data for classroom 5 shows the heating system being activated very early in the morning and on Wednesday the temperature rising quickly to 22.7°C by 3.41am. This pattern is followed for the other days apart from Monday where the heating appears to go off 3 times before reaching 20°C by 9.02 am. The highest temperatures are reached on Tuesday but the

other days follow a very close pattern apart from Friday which hovers around the 21°C mark for most of the teaching day. These fluctuations in temperature require further investigation especially the period between 3.30 and 9.00am where the temperature appears to be maintained at a high level for a long period of unoccupied time.

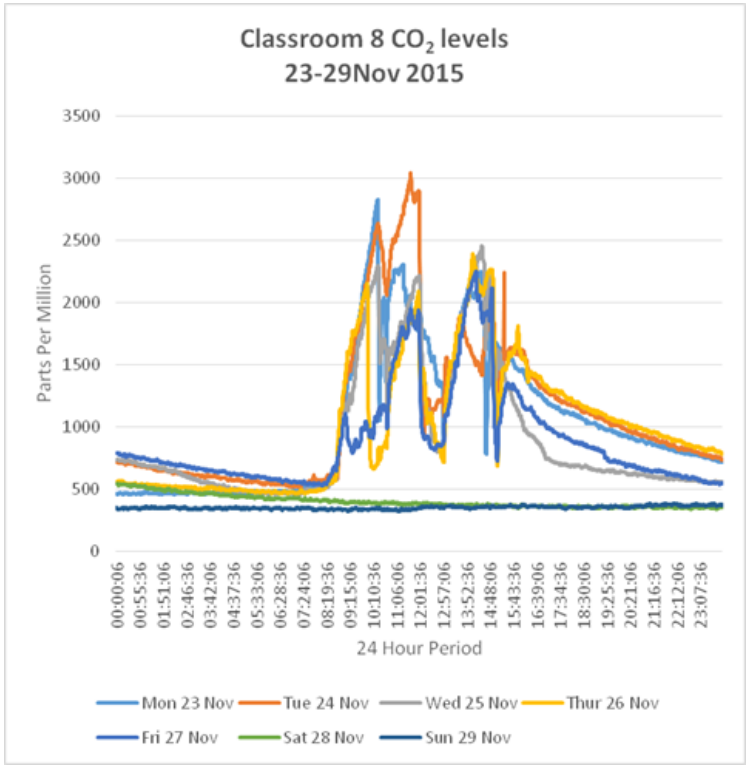


Figure 25: CO_2 levels in Classroom 8 from 23 to 29 Nov 2015

In a similar manner to classroom 5 classroom 8 reaches CO_2 concentrations of above 3000ppm in the second teaching period of the day following a short break after the first teaching period. The CO_2 level rises above 2000ppm every day and the room exhibits very high levels of airtightness with CO_2 rising steeply at the commencement of the teaching day and falling steeply at 3.00pm. Following the pattern of the other classrooms some occupancy is retained for approx 45 - 60 mins and from that point the room is closed and the CO_2 levels fall very slowly and not

falling below 500ppm until 6am and on Friday only reaching a low of 532ppm. As with Classroom 5 ventilation is an issue and an intervention of some sort is required to maintain lower CO_2 levels.

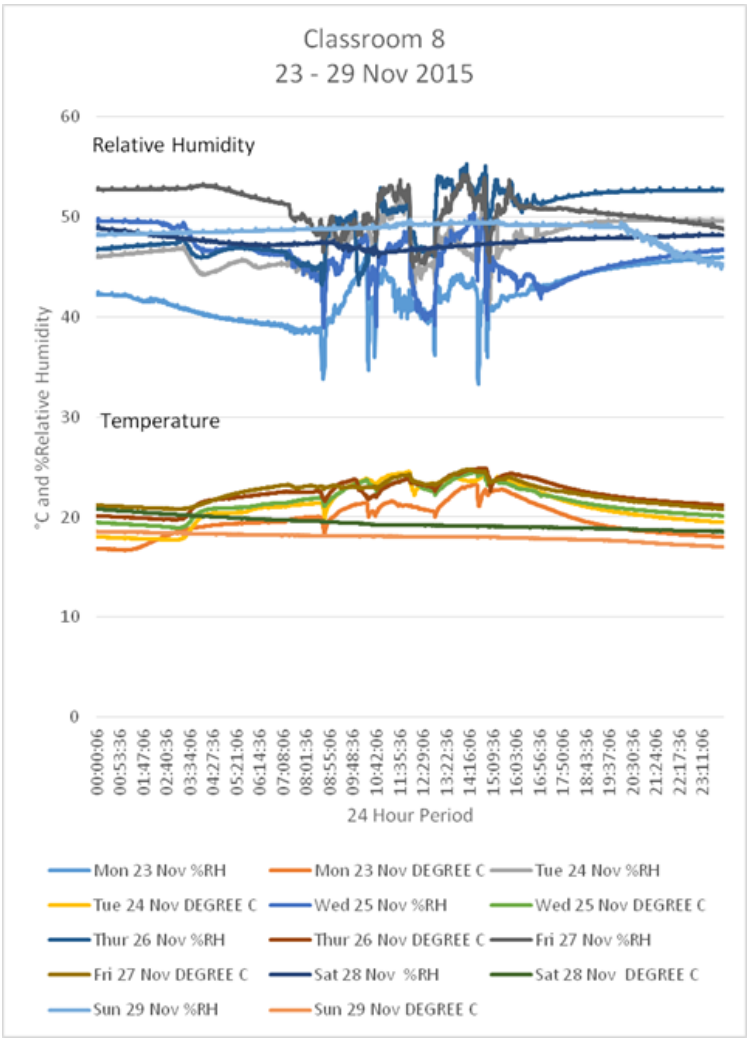


Figure 26: Relative Humidity and Temperature in Classroom 8 from 23 to 29 Nov 2015

Classroom 8 has a similar issue with early morning high temperatures as Classroom 5 and a weekly high temperature of 24.6°C seems a little excessive. The excellent thermal insulative quality of this classroom can be seen in the retention of heat after 3.30pm with the temperature only falling to 21.2°C by midnight on Thursday when external temperatures were ranging from 3-5°C. The RH of classroom 8 is extremely variable but still remains in an acceptable zone of between 33% and 55% although 40% would be more acceptable and could be achieved by simply lowering the heating.

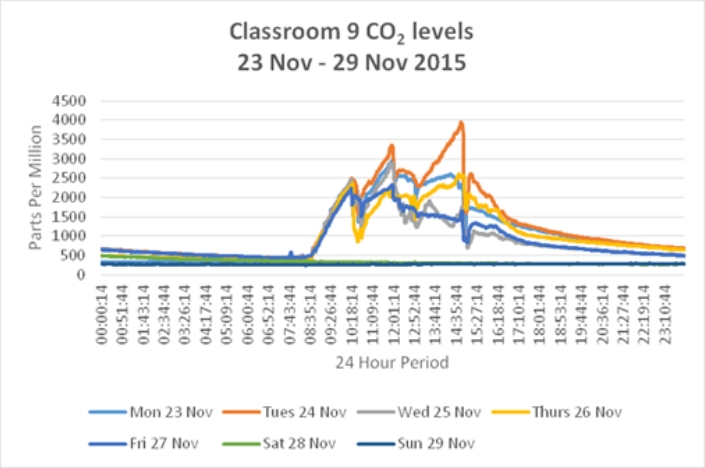


Figure 27: CO_2 levels in Classroom 9 from 23 to 29 Nov 2015

The third period of the teaching day within classroom 9 on Tuesday 24 Nov produced the highest recorded level of CO_2 at 3941ppm which is well above the high levels of CO_2 that Coley and Greaves (2005) described as resulting in a 5% drop in attention levels of the children. The CO_2 data for classroom 9 follows the pattern of the other classrooms in the survey with three noticeable peaks apart from Wednesday and Friday when the room appears less occupied in the final sessions.

The temperatures recorded in Classroom 9 are generally a little lower than the others averaging between 21.5 - 22°C and the early overheating is less of a problem as although temperatures start to rise at about 3.00am they reach 20°C and remain there until about 8.00am when they step up again to 22°C and remain close to this until approx 4pm when they start to fall. On

Tuesday the temperature starts to rise form 3.00am and continues until 7.00am when it reaches 23.6°C and it then falls slightly to 22°C at around 9.00am. Thursday also shows some fluctuations with rising and falling temperatures falling to 20°C at 11.00am. The reason for the lower temperatures may be that the thermostatic control valves on the radiators have been lowered or the heat losses are a little greater for this classroom as it has two external walls. Whatever the reason the lower temperatures reflect in the higher RH reaching 58.6% which is still acceptable for a classroom.

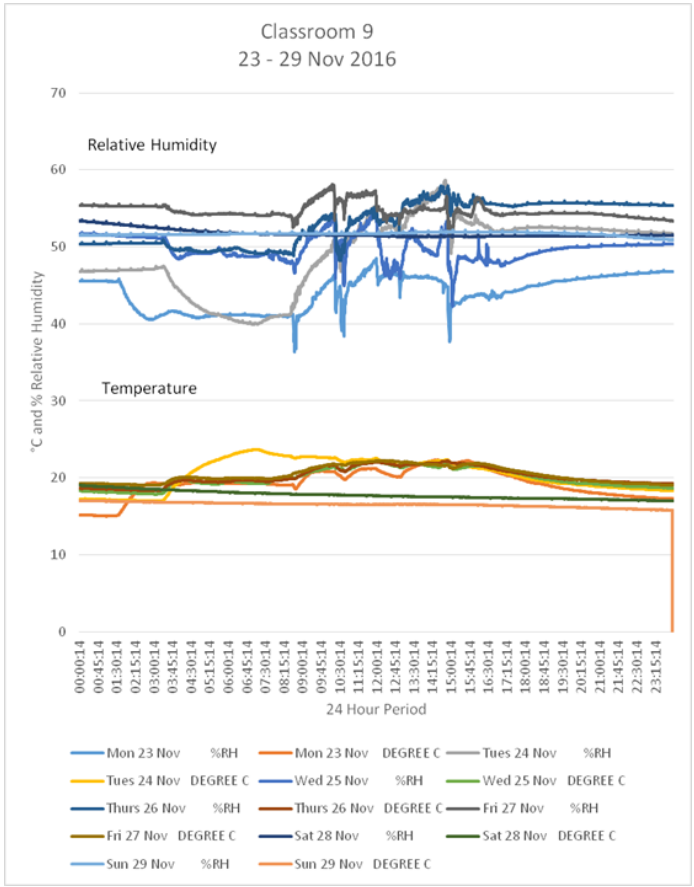


Figure 28: Relative Humidity and Temperature in Classroom 9 from 23 to 29 Nov 2015

The nursery is a large teaching area of 123m^2 and it has an open ceiling and a suspended ceiling making it the second largest void in the school after the Hall. The CO_2 levels in the nursery are shown in figure 29 and it can clearly be seen that better levels of ventilation are being achieved with CO_2 levels not exceeding 2000ppm. The many small peaks shown on the daily graphs indicate the opening of doors, windows or the roof light ventilation although the lack of repetition and the extent to which the CO_2 levels fall seems to suggest it is not the roof lights controlled activation but the opening of the doors on to the outdoor play areas. Once again the very good airtightness is shown by the time taken for the CO_2 levels to recede.

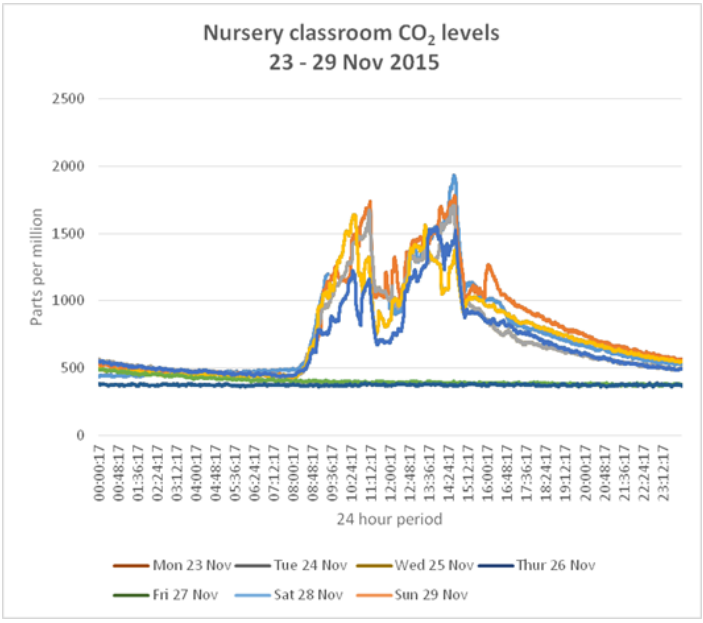


Figure 29: CO_2 levels in the Nursery from 23 to 29 Nov 2015

The Nursery classroom exhibits some very warm temperatures throughout each day and generally rising through the week making Friday the warmest reaching its highest temperature of 26°C at 7.10am. In fact there are high temperatures recorded in the early morning of every day and by Friday reaching 25.2°Cat 4.17am. The data shows that the time taken for the

Nursery to reach a temperature of over 20°C from the lowest temperature of 17°C on Mon 23 Nov is approx 2.5hrs and on Friday when the heating is activated at 3am the room temperature at that time has only fallen to 18.7°C and it then rises up to 25.1°C by 4.15am. This is the most obvious sign that the heating system is activating much too early and this is corroborated with the data from classrooms 5, 8 and 9. This explains why the school energy consumption is so high in the winter months as identified in the degree day analysis.

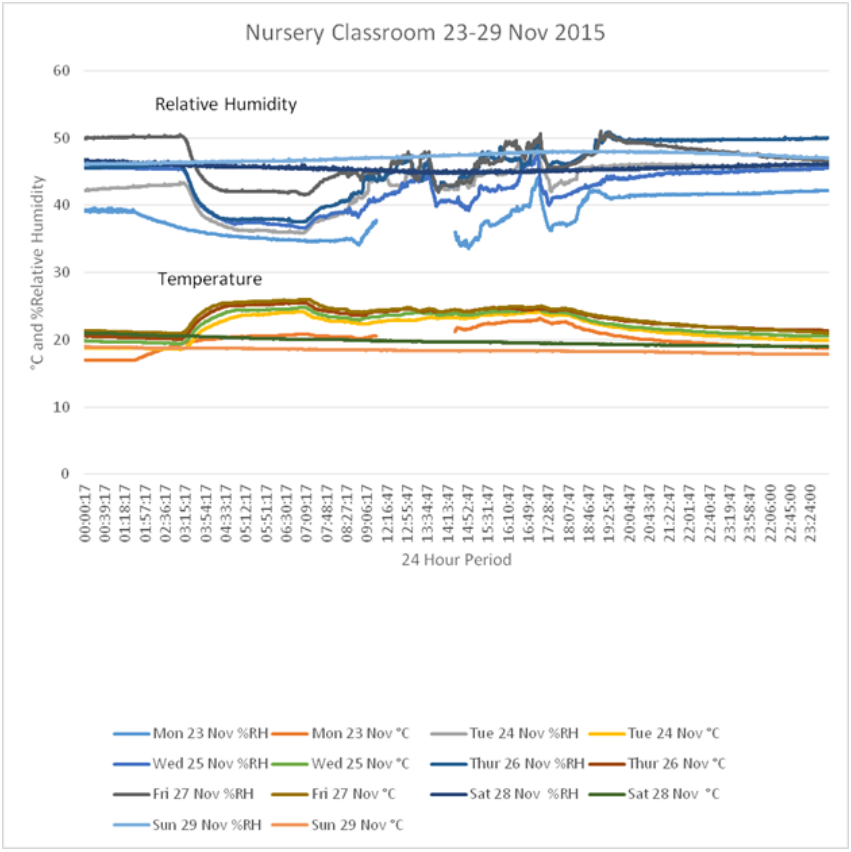


Figure 30: Relative Humidity and Temperature in the Nursery from 23 to 29 Nov 2015 (with a break in the readings between 9 and 11am where the datalogger must have been switched off)

7.6 Occupier Feedback

The Occupier Feedback section attempts to capture as much feedback as possible from the adult staff who use the building and the Building User Survey (Leeman, Stephenson and Bordass, 2010) has been used, in a slightly modified form, to achieve this. The feedback is useful on a number of levels, firstly, it can be used to identify issues that are occurring locally and which may require some remedial work to improve. It can be used to demonstrate the effects measured in the environmental section or the energy use section and it can be used to obtain an overall picture of the schools performance through the experiences of the occupiers. The following extract is taken from the BPCE Report for the modern school:-

5.0 Occupier Feedback

The aim of the occupier satisfaction survey (Appendix 2) is to ascertain the opinion of the users on the performance of the building through their personal experience the process also allows the occupiers to express their own opinions as to how they believe the school could perform better. The overall occupier feedback summary table is contained in appendix 4 of this report and the summary of the written comments is contained within table 5 in appendix 3. It is from a culmination of these multiple perspectives that a judgement can be made on the overall occupier satisfaction whilst it also offers an insight on the effect that particular problems are causing by the occurrence of repeated specific issues that may clearly point to the need for corrective action. This provides the opportunity to combine the condition data , the energy data and the environmental data with the occupier feedback to see if there are ways of resolving reoccurring issues across all of these fields. In this respect the occupier Survey can offer great value in raising the priority of an item of routine maintenance which would not present a high priority in the normal course of building maintenance but when coupled with other issues its priority could change drastically.

The users' perspective is one of the most important parts of any performance evaluation as the people who occupy the building are exposed to the way that the building responds to changes throughout the academic year and they are best placed to assess the suitability of the building to their needs. Their judgement on how well the space, the facility and the micro environment

within the building performs is the ultimate measure of its success. The individual's perception of thermal comfort, air-quality, levels of control and natural and artificial lighting is very variable and are difficult to assesses except by looking at the predominant view in a batch of data for each case (Nicol and Humphrey, 2002). It is important to contrast the information provided by the highest number of adult occupiers of the school as possible including the Head Teacher, all other teaching staff, classroom assistants and the school admin and support staff with data gathered at the same time on the actual performance of the building. The survey format is based upon that developed by Adrian Leaman (2005) which has been widely used within Post occupancy surveys and to gather information regarding thermal comfort, noise levels, lighting, well being and personal control of the space in which people are working. Some general information was requested on the overall design and fitness for purpose. The Likert scale was considered to be the most appropriate with a scale of responses from one to seven allowing participants a good range of options to make a judgement. Twenty two surveys were completed from a wide range of adult occupants of the building which was an excellent response. The staff were asked a range of background questions including their workplace location, how long they have worked at the school, how many hours per day they work in the building, how many days per week and what they do.

The survey was carried out during January and February 2016 occupant satisfaction with the school was still very high as the comparison with the old school made the occupiers feel very satisfied with their new building. The quality of the feedback that was provided by the staff was also very good with a great deal of effort put into the scoring and making their own comments and observations about the school building. The extent of the problems shown in the comments demonstrates that there is a need to improve the environmental conditions within the school (table 5, appendix 3).

The first part of the survey (tabulated and contained in appendix 3) captured information regarding the respondent so as to enable them to be grouped by their location or by the length of time that they have worked in the building. The second group of questions was aimed at identifying the general level of satisfaction with the building overall by asking questions regarding the building facilities, the design and appearance and this was an indication of the overall contentment of the respondents. This was taken a little deeper by asking two questions about the respondents satisfaction with their immediate work area. The overall responses to

these types of question was good with an average score of over six and the image presented by the school buildings and occupier safety being very positive whilst the availability of storage and break-out areas being scored a little lower. Work area scores were also very satisfactory and averages for furniture and work space being over 6 suggesting high levels of contentment.

The next set of questions was based upon the occupants perception of comfort in the winter months and the overall question on winter comfort over the twenty two responses was an average value of 6.4 which is very high. On the question as to whether the building was too hot or too cold in the winter 14 responses were received. Six people rated this question with a 4 so neutral although two answered too hot and five others too cold with scores of 5 and one person scored a 6. This resulted in an average score at 4.4 although the following question as to whether the conditions were stable or variable did receive an average score of 5 suggesting that the situation was slightly variable. The comments recorded in Appendix 3 show that there is a general level of contentment with comfort the school in the winter months with many comments describing the heating as 'comfortable' and 'controllable'. This is in surprising contrast to the recorded temperatures and the high winter energy use as there was only one comment regarding high temperatures.

The Summer comfort question was most commonly answered with a score of 5 suggesting a lean towards comfort, but not greatly so, and this was considered a little unusual for a new building. It was considered to be neither too hot or too cold in summer overall the average was 4 but there were some high scores suggesting it was cold in the Admin area of the school. This was supported by a number of comments about the offices being cold in the summer months. The most repeated comments concerned summer overheating and whilst this was not reflected in the average scores there were a number of comments made suggesting that the school overheats quite badly in the summer months (appendix 3).

The noise levels within school were widely accepted as satisfactory with the average score being 5.9 although there was one recorded comment that when the classroom doors are open to improve summer ventilation the corridor was noisy and disruptive to teaching. There was also comments regarding the admin areas and the lack of acoustic insulation to the small offices and break-out areas. The artificial lighting provision was seen as being very good with the reoccurring score being 7 and the average 6.5 but this scored 4.5 suggesting that there was a

little too much. The question regarding natural lighting asked if there was too much or too little and the average response was 5 so suggesting that there is a bit too much natural lighting. This is a very interesting result as natural lighting was a significant factor in the design of the building and it found to be well accommodated by the final design.

It is important to recognise the location of the respondents as issues within separate areas can be lost in the data if areas are not looked at separately, for example the respondents located in the school office scored their summer comfort as unsatisfactory whilst many others said that the building is comfortable all year.

The building received an average score of 5.3 for the environment having an effect on the respondents health indicating that the building has a positive impact. In Heating, Cooling, Ventilation and lighting all of the average responses suggested that the occupiers have good level of control and that this matters to them. The satisfaction with the overall building design was represented by an average score of 6.2 with only one negative remark on its overall appearance amongst a great many positive and highly complimentary comments.

7.7 Conclusions and School Maintenance and Improvement Plan (SMIP)

This concluding section of the BPCE brings together all of the results and findings and puts forward the initial SMIP which includes the building performance items which have been prioritised alongside the building defects and intended improvement works. It summarises the effect of carrying out the BPCE and highlights what can be done to make an improvement and what has been gained from the exercise. It enables the school to see what areas they need to monitor more closely and prompts them into making decisions as to how they want to use the buildings that they occupy and what they want to achieve from them in the short and medium term. The following passage is the conclusions and SMIP derived from the modern school Report.

6.0 Conclusions and School Maintenance and Improvement Plan (SMIP)

The building condition survey (appendix 1) was compiled in August 2016 has been reduced to a

number of statutory requirements and planned preventative works, there are no urgently required works and all planned works have been prioritised in accordance with the general convention as outlined in table 1A. The issues that have been identified using the energy audit, the environmental assessment and the Building User Survey have been inserted into the SMIP as shown in fig 31 and given proposed priorities and guideline costs.

Planned Programme of Maintenance and Capital Improvement Works	Financial Year	Estimated Cost	Proposed funding source	Notes
Statutory H&S Works				
5yr Fixed electrical test (BS7671:2008)	Sept 2020	tbc	Planned Prop	completed 2015
3yr Gas Safety Test (Installation and use Regs 1998)	Sept 2018	tbc	Building Services Contract	completed Sept 2015
Legionella Risk Assessment (The Control of Legionella bacteria in water systems Approved Code of Practice and GuidanceL8 2000)	2017	tbc	Planned Prop	next review 2017
Ligtning conductor test	2017	450	Planned Prop	item needs to be transferred to Building Services Contracts
Essential Condition Related Works				
Clean out all gutters and flat roof areas	2017/18/19	600	Planned Prop	annual maintenance item
Reapply coatings to vertical zinc cladding above roof level	2017	2000	tbc	possible inherent defect to be referred back to Design & Construction
Clean all aluminium trim and gutters with anti fungicidal wash	2017/18	1250	Planned prop	
Apply timber preservative coating to all outdoor timber structures	2018/19	4500	Planned prop	work to be carried out in phases.
Treat and stain timber gluam cantilever beams to play area canopy	2018	1200	Planned prop	
Energy improvement Works				
Review and overhaul boiler sensors and heating controls	2017/18	1000	Planned Prop	heating system starts too early, setting needs adjusting possible explanation for high energy use in the winter months.

Planned Programme of Maintenance and Capital Improvement Works	Financial Year	Estimated Cost	Proposed funding source	Notes
Investigate erratic electricity use	2017	n/a		The comparison of daily electricity use for occupied school days varies widely each month and further explanation is required. predicted electricity use is significantly lower than actual by 25,154kWh/yr - further investigation and explanation of this is required.
Investigate electricity consumption in August	2017	N/A	N/A	school occupancy to be checked and early August meter readings to be made to accurately establish the electricity use for the unoccupied month.
Environmental Improvement				
Improved ventilation to classrooms to reduce CO_2 concentration and temperatures	2016/17	tbc	tbc	further monitoring required and BMS adjusted to increase ventilation
Summer overheating	2017/18	tbc	tbc	temperature monitoring to continue and measures taken to purge the heat form the building possibly overnight
monitor water use	2017	N/A	N/A	Check water meters reading for August and further investigate highly erratic consumption
Occupier issues				
Improve the use of the ventilation controls in classrooms	2017	1000	Planned Prop	Most of the issues raised by the staff relate to summer over-heating
Provision of acoustic insulation to party walls and ceilings between rooms in the admin area.	tbc	7500	tbc	Identified as being very unsatisfactory by 3 respondents who all work in this area.
Desirable Improvement Works				
EYFS outdoor development work	2019/20	tbc	tbc	
Internal decoration Phase 1	2017/18	5000	planned prop	
Internal Decoration Phase 2	2018/19	6500	planned prop	
Internal Decoration phase 3	2019/20	5400	planned prop	

Figure 31: School Maintenance and Improvement Plan

The overall energy consumption for the School is good and it performs well against good practice gas and electricity use benchmarks. however despite this the school performance could be better as the degree day analysis suggests that too much energy is used during the winter months. One explanation for this was identified from the temperature monitoring data which shows the heating system activating very early bringing rooms up to 23°C as early as 4am and this is clearly a possible cause of the excessive gas use. Another simple explanation could be the setting of thermostatic controls too high producing daytime internal temperatures as high as 25°C.

The school has an excellently performing building envelope with minimal heat losses occurring and heat is well conserved within the building apart from when doors and windows are open to accommodate outdoor play. This may also be contributing to heat losses and the provision of a passable thermal barrier fitted to the external doors could be considered as this would reduce winter heat losses. The gradual cooling of the building that takes place over the weekend periods is visible from the data by the fairly consistent fall in temperatures very slowly from circa 22-23°C down to a low of only 18°C or so by Monday morning when the heating restarts, reflecting the excellent u-values of the envelope. This is an indicator of how energy is conserved by enabling the building to stay at 18°C the work that the boiler needs to do to bring the school back up to operating temperatures is much less than if the building was allowed to fall to lower temperatures.

The monitoring of the environmental conditions within the school classrooms took place over a four week period from 6 Nov15 to 4 Dec 15 and the data logging was carried out within four classroom areas and the school Nursery area. The results suggest that there are unacceptably high CO_2 concentrations during the teaching periods and that measures need to be considered to improve the classroom ventilation. The classrooms demonstrated very good air tightness by showing sharp increases in the CO_2 concentrations early in the school day and in all periods of occupation and a slow return to unoccupied levels when the school day ended.

The lighting survey showed some differences between rooms where the lighting levels were set differently possibly reflecting the flexibility of the installation enabling different levels to be provided to suit the classroom activity. The lighting installation appears to be exemplary in its

performance and its energy use.

The occupant satisfaction analysis provided a good indication of thermal comfort levels and the general contentment of the occupiers with the new school building. The feedback from a majority of occupants was very positive although some remarks suggesting summer overheating may be a problem in some areas and acoustic insulation could be improved in some areas. There were also comments about the air flow through the building and how this can be excessive at times when the local weather conditions produce gusty winds.

Overall, in terms of energy use, environmental impact and the occupier survey the BPCE has identified a small number of issues which can be incorporated within the SMIP. The building has been identified as performing to a level well above average and provides a comfortable environment for all of the occupants.

7.7 Appendices to BPCE Report

The appendices referred to in the Modern school Report are contained within Appendix III of this document.

8.0 Analysis of BPCE interviews

Interviews have been seen as processes of construction in which respondents constitute worlds of meaning and make sense of their experiences (Mishler, 1986, p118). However the relationship between the interviewer and the respondent shapes how the dialogue progresses and must therefore be integrated into the analysis process. Interviewing provides a rich source of narrative analysis and this can sometimes make it difficult to define what is to be analysed. The material of the interviews is a complex collection of verbal and non-verbal communications made more complex by the changing interaction between researcher and participant. Thematic analysis has limited interpretative power beyond mere description if it is not used within an existing theoretical framework that anchors the analytic claims that are made. In the case of this study the response is heavily weighted over the non-verbal communication and it was the intended to try to capture some of the non verbal communication in the descriptions of the responses.

The interviewee's agreement to cooperate with the interviewer was not taken to mean that their responses were limited to what they are being asked and a considerable amount of open discussion took place around some of the questions, the interviews were a complex and unique interaction of responses. The process could have been described as 'collaborative meaning making' (Esin et al, 2014). However the purpose of the exercise of reducing the narrative strands of the interviews was recognised as better served by recording what the interviewee actually said rather than by translation into the interviewer's words. It is believed that retaining the quality and character of the original data can only be achieved if the original voice is retained; that is the meanings as expressed by the interviewee (Gillham, 2005, pp127-129) and this was the intention in summarising the transcripts.

A thematic analysis of the responses from these questions was carried out using a coding method similar to that deployed in the initial study. This involved an analysis of the transcripts from each interview identifying substantive statements and deleting the 'small talk' or 'padding' and repetition. There was some re-ordering as the discussions often returned to earlier questions and there was some comments made which more appropriately answered earlier questions. The respondents frequently asked questions about the content of the report and further explanation of various techniques used. This required some immediate consideration and response and even some debate over the matter and in one or two cases further comment by email following the

interviews. In the majority of the cases the Head Teachers were familiar with the content of the report as numerous conversations had taken place, sometimes over the course of many meetings, regarding the purpose and value of the techniques in the report long before the issue of the questions.

The participants in this study were the head teachers of ten primary schools seven of which were located in the Preston area and three in the Burnley area of Lancashire. They were all female and the length of their experiences as head teachers ranged from two to twenty eight years and all were interviewed by the author. Each interview was digitally recorded and then transcribed so as to enable the analysis to take place using a pattern coding strategy (Miles and Huberman, 1994). A sample of the coding exercise for the interview analysis is contained in appendix II and the interview sources are the ten head teachers that were selected for interview annotated school 1-10 in the table. The coding is then grouped into patterns and then grouped again into themes and finally these themes form the basis of theories. The interview questions have been summarised individually as follows:-

Question 1 what are your first impressions of the BPCE?

In many cases this produced a response of 'well' then a pause and then a general but revealing comment about the overall content. In more than one instance the initial comment was *'it is very large'*, *'it was a bit heavy going'* and *'it was very heavy'* or *'it was very technical'*, or *'a bit too technical for me'*. these comments were then frequently qualified with the preposition, *'but'* and then followed by a more thoughtful remark like *'parts of it were very well presented'*, 'it was very interesting in places' or *'I really liked….'* or *'can you explain'*. The overall response was generally a little negative and the first impression of this 60 page report was that it would be a great effort to read and understand it all because of its technical content. Many Heads made the comment that they would like to have held a meeting and be taken through each chapter with some discussion and further guidance about what everything meant and in some cases that is what followed. One head teacher stated that '*It was well over my head and I don't see any point on making comment on it really'* although this position was later changed and further comment was made by this head.

The responses, beyond the initial remark, fell into two distinct camps; those which were negative and asking for more explanation and those which were positive form the outset and claiming it

to be ‘a very good idea’. The first impressions were generally split between those who claimed that that the report was daunting and more than a little off-putting by its size and that the content was too technical, and those who immediately expressed satisfaction stating that this information was ‘long overdue’ and that it was ‘really good’.

Question 2 Do you think that any form of Building Performance Evaluation would be worthwhile and what would you say would be the most significant information to be gathered within the evaluation?

This question drew out a much more positive response than the first question as every head interviewed thought that some parts of the report were particularly useful and comments about the CO_2 levels in teaching areas were made in every response. The responses ranged from those which started with *‘I don’t know really’* to those who immediately proclaimed the BPCE to be *‘all worthwhile’*. One response seemed to sum up many of the issues; *‘I don't know really, there are such a lot of things to consider ... I think the energy information asks a lot of questions and identifies further work required to be done and I think that the CO_2 levels in the classrooms are good to measure so that we know what are teaching conditions are like...I think overall it is a good thing but who's going to pay for it?’*

Over half of the heads thought that all of the report was very valid and worth capturing and even though some of the heads did not understand the technique being used they understood what the findings were saying and that this data could be passed on to other professional advisors like the building services engineers for further investigate and for them to resolve the problem.

The concept of Building performance Evaluation was clearly recognised as being potentially useful in terms of improving the teaching experience. It also made the head teachers think about their internal environments a little more critically. One Head remarked that ‘*we didn’t realise that the lighting levels were so poor until it was pointed out to us we had obviously just got used to them’* and another Head of a school built in 1908 commented that *‘we have a number of teaching spaces and the library which we now think are poorly ventilated’* .

There was some reticence in terms of setting precedents for example by refurbishing one classroom and creating an excellent teaching environment other areas of the school then look and feel much worse by comparison. There was a concern amongst some heads that id they acted on the incentive of improving poor quality internal environments in some classrooms it would be

assumed that this would follow on through the school and whilst this might be a reasonable expectation it might impact some medium term improvement plans for the head teacher.

Question 3 Would you see any of this information influencing decisions that you would be involved with for larger planned or improvement works projects?

This question brought a range of responses from *'I don't know'* to *'absolutely'* but in all cases after a discussion about the implication of not acting on some of the building performance issues the overall response was that the building performance issues did have a high priority, particularly regarding such things as where CO_2 levels in classrooms were at an unacceptable level and where immediate savings could be made by better heating controls or the installation of low energy lighting. The prioritisation of building performance issues alongside the general building maintenance issues was generally seen as being a good idea and the report was regarded as having clarified this in almost all cases. The comments about this process revealed how the report has introduced some new thinking on this matter one Head commented that' *we wouldn't consider installing our new windows now without knowing that we had adequate ventilation'* and another said that *'we would love to know why our electricity use is so high, finding out why this is the case is more important that painting the hall and corridors this year'*. The overall opinion on this question was that building performance issues should be prioritised with the other building maintenance, building services and minor improvement works and decided upon with consultation with the head teacher as shown in the example SMIP.

4. Do you think that any of this information should be gathered with the condition appraisal and used to inform the planned building maintenance programme?

This question produced a mixed response with many head teachers suggesting that some of the investigations should be carried out routinely and that others should be carried out only when there is evidence of a problem. One head commented *'why would you spend money on looking into something where there was no reason to believe there was a problem?'* However, the majority of head teachers thought that the measurement of CO_2 levels in classrooms should be carried out routinely possibly with the condition survey and that proposals should be presented to resolve the problem in both the summer and winter terms. The overall theory derived from the coding exercise was that there was some uncertainty and a need for professional advice in

making decisions between building condition and building performance issues and there were concerns that work identified would not be able to be funded from the school budgets. The majority view of the head teachers was that almost all the content was of some value and that there was merit in carrying out all of the report at least once and then reviewing the building condition information annually. The concerns about the cost of work being identified could be seen to be the heads concerns that their plans for improvement works would be stopped or that funds would need to be diverted from elsewhere in the school budget.

5. Do you think that the cost of producing any of this information could be justified even if it did not result in making savings?

The head teachers expressed concern about the cost of producing the report as indicated in the quotation in response to question 1. However almost all of the respondents said that they would be prepared to pay to have the CO_2 levels in their classrooms checked and as part of this exercise they would also like to see the temperature and relative humidity monitoring. The suggestion here was that they would not wish to monitor the relative humidity or the temperature as a matter of course but as the datalogging devices that monitor the CO_2 levels also monitor the relative humidity and the temperatures they would want them included. Most heads admitted to only paying scant attention to the schools DEC however they pointed out that there was energy use data in the DEC and roughly a quarter of the heads said that they would only want further energy investigation if the DEC was telling them that they were using energy well above the recommended benchmark.

Most of the heads expressed positive opinions about how well the energy data was presented and that this was a very clear demonstration of the schools performance. They also found the relationship between the gas used for heating, the number of degree day and the number of days of school occupancy per month. In both of the examples these figures did not correlate well together with the Victorian school showing high variations from the predicted performance based upon the external temperatures. Whilst this made the heads interviewed curious as to how their school would measure up, it was looked upon as something they would only look at if they were being advised that there was a problem with consumption. About half of the heads did want to know that their classrooms were being kept at 18-20 degrees C in line with the DfE guidelines and that the relative humidity was within the acceptable range. Interestingly they did not think that a cursory check of a thermometer was good enough and they expressed a preference for the

minute by minute monitoring. *'I would want to go through the full monitoring process in every classroom in the winter term time to show exactly what was happening, I think this is good'*

6. Would you be interested in developing/providing a sustainability strategy for the school using information from this Report?

This question received a varied response with the most popular answer being yes *'to a certain degree'* and *'if it were not at great expense'* and *'yes if we could involve the children in some way'*. The desire to have a good and working strategy for the school with achievable targets and outcomes that would offer some merit to the school was very strong. the other end of the spectrum were a couple of heads who immediately dispelled the idea as being a lower priority for them at the moment. This was referenced to *'not a lot of time available for that sort of thing at the moment'* and *'this if off our radar right now'*. On the whole the idea of developing some sort of sustainable strategy was accepted as a good thing to do and may schools are already part of schemes which involve achieving various staged levels , e.g. the Eco Schools programme.

7. Do you see any merit in formally capturing the opinions of the teaching staff on the performance and suitability of the building for its purpose as a primary school ? Are there any disadvantages in doing this?

Most of the heads were able to describe how feedback from their staff is currently obtained, usually by someone feeling strongly enough about something to bring it directly to the attention of the head teacher or by passing a comment informally in the staff room. When they examined the survey format and the feedback schedules they could see what a comprehensive evaluation of the building this represented with almost the entire staff of the Victorian school expressing their feelings about the performance of the school many making comments in the boxes provided to add further information on their scoring. Almost all of the head teachers liked this process as it was and effective means of capturing the feelings of the staff and proving a summary of the building performance from the perspective of the building user. This feedback could, in many cases, be responded to by looking to do work to improve an area or a defect that had not been previously identified. It provided another source of issues affecting the performance of the school which could be included within the SMIP and enable them to be prioritised as occupier issues.

There were some comments regarding the possible downside of the user survey such as '*what if we simply don't have the funds to do anything about them will this not be bad for staff moral?'* and *'what if the staff come back with dozens of issues, isn't this just be a statement of how bad the school is, and if we can't do anything about it'*, also *'by asking the question, asking them to think about it , are we suggesting that we are going to do something?'*

8. Do you think that the occupier survey offers any useful feedback for the asset/ maintenance management process?

Most of the interviews addressed this matter in responding to the previous question but it was generally accepted that the staff responses could be useful in discovering issues that may otherwise have been unreported and that may have implications significant to the overall operation of the building. Many of the heads felt nervous about raising expectations and suggesting that the questioning need to be carefully posed; *'if it were put to the staff in the right way'*. The heads felt it necessary to be '*open and honest'* in the approach and explaining about the scarcity of available budgets to do any work identified by this method. The heads were also nervous about how to explain what work would be carried out and what funding could be put to these issues and how the worst areas would need to be tackled first. However in the two surveys that were completed what was found was that there were numerous small cost issues that made a difference to the occupiers and as the heads were intent on doing some of this work staff moral was expected to rise as a result of the exercise. Perhaps just as importantly it could be argued that the efficiency of the asset management process was improved by diverting funds to those issues which made the biggest difference to the occupiers and therefore the overall performance of the asset. The preservation or enhancement of the building asset might not have been affected by the action of repairing an area of flooring or redecorating a classroom or providing some external lighting to the car parking area but if you consider the overall performance of the asset as embracing all aspects of the use of the building it is a strong argument to say that this approach is actually getting more from the asset. ISO 55000 defines Asset Management as the *'coordinated activity of an organisation to realise value from assets'*. It also defines an asset as *'an item, thing or entity that has potential or actual value to an organisation'*. In considering these definitions the view of the purpose of asst management as enhancing the user experience seems appropriate to this kind of activity.

9. Is the environmental appraisal of any use in the asset management of the school?

This question is related to question 6 with regard to the environmental impact of the school and the pursuit of lower CO_2 emissions, recycling, waste management and water use and there is a genuine desire to look at measures with regard to protecting the environment. However these issues seem to have been placed at a lower priority level than some other issues and a number of heads acknowledged the importance but failed to devote resources to any particular initiative in this field. The internal school environment was however looked upon as an important aspect of the report and, as highlighted in the responses to question 5, the head teachers were particularly concerned to ensure that they were providing good air quality to their teaching areas. Responses such as 'I think that the measurement of air quality is important' and ' having children at their most awake is a vital part of the teaching process' . Also the report raised concerns where there had previously been some doubts about air quality; 'I dread to think what the CO_2 levels are in Rome classroom and 'I have always thought that the mobile classrooms were very hot and stuffy in the winter'. In both of these two examples the CO_2 levels were monitored for a period of approx 3-4 weeks and found to be over 6000ppm in both schools. as a consequence Rome classroom has now had a mechanical ventilation and heat recovery unit installed and the windows replaced. The overall view of the head teachers towards the subjects of recycling, waste management was that they were not necessarily something requiring regular monitoring but are just initiatives that should be set up and allowed to run. This is understandable and they are perhaps inappropriate for the BPCE assessment. The general opinions on the measurement of water use was that it was a good idea to check the usage was reasonable but there was some division of opinion on whether it could be justified economically. *'I think it is the right thing to do'* and '*I would want the children know that we need to save water' were* typical comments in favour but other voices were not so sure *'I think we are ok at the moment..not sure who measured it but I would not see it as something we would want to do on a regular basis'*.

10. Do you think any of the Energy analysis is of any use in the day to day running of the school, if so what do you see as having most benefit?

Almost all of the head teachers were impressed with the presentation of the energy data and found the accompanying explanations understandable. They did not however have a clear understanding of the degree day analysis beyond the linear regression analysis and further explanation was required. In the sample reports the summation of the electrical energy used by the school appliances, the kitchen, the lighting and allowances for electrical energy associated

with the heating and fire and intruder alarms did not match the actual energy consumed. This gap was explained as either unaccounted energy use or due to the approximate nature of the assessment of the energy used by the school appliances. When the process was explained to the heads they understood that the school appliances energy use was based upon an approximate time of use in the average day and although this could lead to inaccuracies they accepted that their close monitoring of the appliance use would improve the accuracy. If the unaccounted energy use was large most of the heads said that they would have wanted to proceed with the exercise and carry out more detailed investigations until the unaccounted energy use was identified. This clearly demonstrates the increasing pressure on school budgets and the heads' desire to reduce costs wherever possible. It also demonstrated how the report could help them in doing this by providing them with the basis upon which to build a greater understanding of exactly how their energy is used. From this position of knowledge most of the heads felt they could affect the energy use or at least ensure that wastage was monitored and more closely controlled.

9.00 Conclusions

9.01 Achievement of Aim and Objectives

The objectives of this research represent the development of an idea to combine the condition appraisal process with an evaluation of building performance. The purpose of these objectives was to define the current position and to show how this idea could be contributory to the asset management process. The final achievement of the aim was to produce a systemic model of a process that would represent an improvement on the current practice. The aim and objectives have not changed significantly throughout the research and have withstood a great deal of cross examination and reflection. The conclusions that can be drawn from the achievement of the objectives can now be summarised.

The first objective involved a detailed examination of the development of Post Occupancy Evaluation and Building Performance Evaluation. These two terms were found to be loosely applied to any group of techniques that involved an evaluation of the performance of both new and much older building stock. The literature provided a chronology of different understandings in the nomenclature and the content with some methods containing a considerable array of techniques aimed at providing assessments of an extensive range of performance indicators from 'furniture arrangement' to the 'health and attainment' of the occupiers. The literature was used as a part of the process of condensing these techniques into a group of the most significant for use in a primary school setting.

The second objective was to determine the existing asset management processes and the extent that data was gathered for the purpose of managing the built asset. This involved a review of the literature and the setting around this subject identifying the changing nature of the priorities within this subject field. A knowledge of this area was important in understanding the apportionment of resources both surveying and budgetary as well as an understanding of why changing activities were necessary and what was gained from them. This objective was achieved form an evaluation of the literature and through the initial study interviews, especially of the senior management. The main conclusions to be drawn from achieving this objective were that the processes deployed for capturing data on the schools have for a number of years been entirely condition led and that they have been tailored to inadequate budgets leaving the schools with a backlog of building condition work.

The third objective was achieved through the initial study interviews of the participants in the specific environment in which the research was conducted. Gaining a thorough understanding of the perspectives of the groups involved was critical in the use of the selected methodology. Within the three main groups identified, i.e. The head teachers, the professional advisors and the senior managers, there were distinct biases and the participants were generally unified in their group beliefs on the asset management processes deployed. Taking their individual prospectives and building group worldviews enabled the rich picture to be compiled. The conclusions from completing the third objective were a much improved understanding of the overall process and a grasp of how complex the scenario actually was when examined in this way.

The initial conceptual model was built from using the root definitions and purposeful activity models which was the fourth objective of the research. It was a process which raised questions of the model which led to further refinement. Each of the four sections of the BPCE was then examined with reference to the five Es criteria and analysed using an integrative framework by making comparisons with the existing asset management process. When considering how each of the evaluating criteria would be seen to be affecting the BPCE or how they might be perceived to be operationalised a number of key factors were identified and these are summarised in table 6. In completing this process the fifth objective of the research was completed and a number of conclusions were drawn from the comparative analysis strongly endorsing the BPCE over the existing practice.

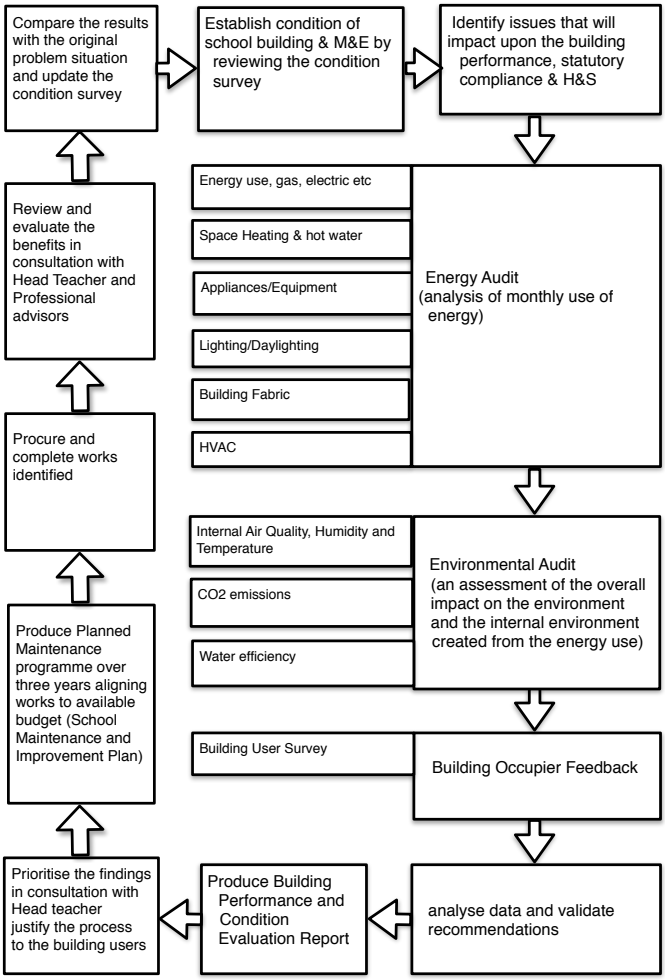
In the attainment of the sixth and final objective for the research a group of interviews was conducted with the people to be considered most affected by the BPCE i.e. the head teachers. As they are the budget holders and the managers of the activities carried out within the buildings they were identified as the most relevant to consult in the final assessment of the BPCE. Their comments were invited from the semi-structured interviews and the feedback was then subjected to the same thematic analysis as was carried out in the initial study interviews. This had the effect of enabling a further refinement of the proposed BPCE into its final content and combined with the process the systemic model was produced thereby completing the Aim of the research.

The overall response to the BPCE Report from the head teachers was generally good and summed up by the head teacher of the Victorian school used for one of the BPCEs when she said *'Overall I am impressed with the report and with its content and perhaps it could be done as a*

one- off activity or better still as part of the on-going maintenance regime.' other head teachers comments included '*I think it is a good and very worthwhile report that would really give me something to work with'* and '*it would be comforting to know that we are teaching in good environments.'* There was a general acceptance that some of the issues raised by the report were important enough for schools to measure and to know about, such as the CO_2 concentrations, and some things might be better approached when issues are identified or suspected. The examples of the two schools who strongly felt that they were teaching in poor classroom environments shows how particular techniques within the report could be used. It was also acknowledged by one of the heads that *'the CO_2 levels might not appear to be too high in the winter months when the windows are closed to keep the heat in but until you measure them you won't know what they are and they might be over what we would want'*. This is of course true and what appears to be good most of the time might, in particular circumstances, become unacceptable such as was the case in two of the classrooms of the modern school where CO_2 levels were exceeding 3000ppm where the natural ventilation had been overridden.

The building user survey was generally accepted as a good way of identifying issues that are annoying to staff and possibly counter productive. The disadvantages in carrying out this sort of survey were considered to be outweighed by the benefit gained from a number of perspectives. The exercise generally was well received and people wanted to contribute to the process and understand more about how budgets were applied to the needs of the school. one of the interviewees identified that *'there might be a risk of people not being bothered to fill in such a long form'* and this prompted a view that the survey could be shortened to just those issues that could be verified from the other data, i.e. the summer and winter comfort, environmental control, lighting and noise issues. this would involve leaving out the other questions about overall design, work area and suitability. The head who raised this point had suggested that the questions around how long the person had worked in the building and how many hours per week they occupied the building were not useful to her and she was also aware of the need for small learning support areas and additional storage space. The points raised were considered to be useful and were acted upon in producing a revised occupier questionnaire as the data referred to was not being well used in the evaluation. The revised Occupier questionnaire is contained in appendix II.

The initial study brought out some of the intricacy of the prevailing scenario of property **Figure**



32: The Systemic Model of the application of a BPCE for a primary school

management within the local authority used for this study. It showed how the adopted approach involved not using large amounts of the building condition data being captured and the short

term programme (SMIP) was being developed without much adherence to the building condition survey data. The process focused more upon the discussions between head teachers and their professional advisors who were guiding the opinion as to how the school's resources were to be committed over an approximate period of three years.

The intervention of the use of the BPCE offers a transition to an improved position which is demonstrated in the systemic model which has been developed and shown in figure 32. The model represents the combination of the condition information, the environmental assessment, the energy audit and the occupier feedback and how the process of using this information in the asset management process works. The systemic approach can be seen as one which adopts a process to determine the viability of a project or procedure based on the experiential application of clearly defined and repeatable steps and an evaluation of the outcomes. The goal of a systemic approach is to identify the most efficient means to generate consistent, optimum results and to produce an emergent property which offers a systemic benefit from doing any of the activities in isolation.

The pressure on the head teachers and their staff to produce better academic results from their children under their tuition is clearly a factor in the responses received to the BPCE. Some of the heads were interested in measuring the benefit to the pupils academic performance and although this was never intended to be a part of this research it may well be a future direction for further research and some work has already been undertaken in this field.

9.02 Limitations of the research

The findings of this research have been established using a rigorous methodology, methods of collection of data and interviews which have been conducted over a period of five years. During this time their has been opportunity to reflect upon the direction of the research and in the course of day to day activities and contact with head teachers and professional staff at the authority opinions have been sought and discussed adding to the overall substance of the reasearch. By carrying out the research in this way the objectives were all achieved and the Aim of the research was realised in that the BPCE format produced was an outcome of following the devised process. However there are some limitations and delimitations to the research which need to be considered. Limitations can be defined as those characteristics of design or methodology that

impacted or influenced the interpretation of the findings from the research. They are the shortcomings, conditions or influences that cannot be controlled by the researcher that place restrictions on the methodology and conclusions. Delimitations are choices made by the researcher which describe the boundaries that have been set for the study such as population/ sample, treatments, setting, and instrumentation.

The main boundary that was set for the study was the decision to use only two specific BPCE reports and then use them as example reports to gather views from other heads from similar types of school. There was a benefit in producing reports for schools and then interviewing the head teacher for that school as they could relate to the actual issues identified. However the additional benefit of doing this compared with using a sample report was not considered to be worth the very considerable additional effort required. In producing school specific BPCEs there was a great deal of repetition ie collecting data from light fittings and tabulating these to form part of the energy use simply showed the head that this is how much energy that is used for lighting. This could easily be done with the sample report by discussing to what extent the situation could exist or was likely to exist in any other school. The additional time that it was estimated to take in producing three or four additional BPCEs would also have resulted in lengthening the time for the research and it was therefore considered not to warrant this.

An important delimitation in the use of the methodology for this research could be viewed as the omission of the social and political analysis of the culture of the interaction of the groups of contributors. It was not considered necessary to include any analysis of the social and political characteristics of the situation as the prior knowledge of the author having worked in the midst of this environment for the past five years would undoubtedly mean that the culture of the situation would be embedded in the research. No effort was therefore made to consider the roles, norms and values of the social and political settings involved in the way contained within the methodology.

The strong regional focus of the schools in the sample could be viewed as a delimitation as they are split between just two towns in a large northern county. The research would have been stronger for using schools from other towns in other controlling authorities or academies. The sample of schools that were used were selected from a group of schools with which the author is very familiar and the head teachers from these schools have been in regular contact and

discussions with the author. This has led to a familiarity with the research which might be said to skew their interpretation of the BPCE process and make their response different from head teachers with no prior knowledge of the content, its value or the author. When it was discovered that this might be a problem the selection of all eight of the schools using the sample reports were made from of schools with head teachers who had no prior knowledge of the research thereby limiting the effect to just the two schools where the BPCE reports were produced. This does not seem to have been such a significant problem as first envisaged as the findings from the interview process were fairly consistent across all of the schools.

In the analysis of the environmental conditions in the classrooms the data was collected over the period of three to four weeks and one week was used to show the typical classroom conditions. On reflection more of the data collected could have been used to establish the typical conditions and although this would have taken much longer to produce, a more accurate assumption could have been made from the larger batch of monitoring data. The measurement of thermal comfort was carried in broad accordance with ASHRAE 55 section 7 and numbers of respondents and the nature of the responses requested was as outlined in this guidance note. The temperature measurements were not made at the three different heights but with one set of data acquired from the datalogger at a height of approx 1.4m above floor level. The instruments utilised to capture the monitoring data of CO_2, relative humidity and temperature were capable of capturing temperatures to an accuracy of +/- 0.8°C at temperatures from 0 to 50°C. The relative humidity could be measured at an accuracy of +/- 4% which was considered to be a reasonable accuracy. The Extech SD800 has a NDIR CO_2 sensor which is an optical detection unit based on non-dispersive infrared method. It is acknowledged that CO_2 sensors based on the NDIR principle are accurate, allow fast measurements and have a good long-term stability (Boudaden et al, 2017). The sensors therefore offered a sufficient level of accuracy for the purpose that they were used i.e. to distinguish between CO_2 levels were low, medium or high, to demonstrate the extent of variations in levels and the rates of build-up and decline. The data captured is in many areas of an approximate or estimated nature for example how much time appliances are used in the average school day or how long the lighting is used in any particular area for an average school day. Some of the head teachers did recognise this and saw an opportunity to look at monitoring this and refining the use figures to provide more accurate data.

One of the boundaries or delimitations of the research involved the decision to interview only head teachers for the final stage of the research. The objective was to assess the benefit of adopting a defined set of practices and to undertake the final refinement of the report content and how it impacts upon the existing process. The decision was taken from the start that this final perspective was to come from the head teachers, as they are the most affected party, but in terms of achieving the objective it would have been an option to invite the opinions of the other groups such as the Asset Managers, and this may be a course of future research on this subject. The content of the report is technical in nature and although it is representative of what has been previously justified form the earlier work, this set of questions could have been put to other groups and in particular the technical practitioners and this would have provided a broader set of data upon which to judge the desirability and feasibility of the proposed approach.

The overall reliability of the research is generally acceptable but the process is complex and subjected to on-going change depending upon the views expressed by the participants. If the research was carried out again using the same principles it should yield similar results, however each section of the report contains subjective aspects which could produce a different result where choices are being made by participants. Clearly even if the same typw and numbers of actors were interviewed then the detail of the report may be different as the subjective opinions, even of a group of people doing the same job, could not guarantee a similar result. If the condition survey were carried out by a different surveyor the result would most likely be slightly different as the nature of making judgements on the quality and condition of a building element is subjective. The process of measurement of the internal environment and the placing of the findings in a suitable priority in the SMIP should be repeatable using equipment capable of delivering the same levels of accuracy. The energy audit and the degree day analysis should also be repeatable and place an appropriate emphasis on any work that may be required to improve the situation. The occupier feedback is dependent upon individuals wanting to contribute to the process and so this may be highly inconsistent as people may feel differently about their environment depending on the prevailing conditions at the time they are asked. The occupier feedback was generally gathered in the winter and the comments about issues with the winter conditions produced significantly more than those for the summer. It may have been preferable to obtain feedback from the occupiers during the early autumn rather than mid winter and to gather the internal environmental data during the winter. The overall position of the BPCE is that

it may differ in its outcomes for different sites but the overall application is a consistent process that will deliver a more efficient and effective means of managing property assets.

The validity of the findings are one of the significant strengths of the report in that there is cross-verification of finding between the different sections. for example if the energy analysis suggests excessive gas consumption for heating and people in the school claim to be too hot and the temperature measurements are high then it is very likely that there is a problem with the temperature control of the heating system or if the condition survey suggests the need for replacement windows and heat losses are high and people complain of drafts in the winter and lack of opening windows in the summer then the decision to prioritise the replacement of the windows should be high.

In considering the question of the internal validity of the research the processes applied and all of the measurements taken in conducting this research have been supported by the evidence of the literature review and the application of the data in the processes of the report. The presence of a great deal of triangulation within the research is in many ways a demonstration of the internal validity and there are many aspects of the research where measurements have been taken to provide evidence to be meaningfully compared to some known benchmark. If these results were found to be varying by a great degree then the findings would have been suspect.

The occupier feedback from the primary schools was based upon the teaching staff who are generally located throughout the working day in a specific room within the building. However, it was clear that some of the participants based their comments on the building as a whole or as they experience it including the classroom where they work and the common areas the hall and the staffroom, reception etc. The final interviews with the heads produced some interesting feedback abut the building user survey and this is something that could be adjusted for this exercise where no specific investigation was attempted about the time the person has worked in the building or what they think of the overall design. These issues could have been used to examine the frequency of negative comments and to look for a relationship between the time a person has worked in the building and the number of negative comments. As the research did not investigate such things as it was not considered significant then there was no point in capturing them and the survey could be reduced to something containing only opinions on the issues under investigation.

9.03 Implications for Theory

The external validity of this work is very important and has been a consideration throughout the research as it is likely to be very beneficial to generalise these results beyond this study. One of the conclusion from the exercise is that by producing the content of the BPCE so that the information from each section of the BPCE justifies or conflicts with information in other sections strengthens the decision making process and the prioritisation procedure. This corroboration process gives the BPCE system its emergent property ie the enabling of better decision making through the consideration of condition and performance factors in the asset management processes. It therefore raises the question that if this procedure applies to primary school buildings could it also apply to other sorts of properties? The BPCE should be applicable to any property which is occupied and being put to a use. This research has concluded that utilising the resource necessary to carry out an assessment of building performance and combining the data gathered with the building condition data offers a more informed and improved decision making process for primary schools and many their building types.

One of the most important implications in the theoretical development of the POE into the BPCE is the reduction of the collected and measured data into only the most useful and relevant. This data can be used to some fiscal advantage by the school, almost all of the input from the head teachers was based upon how the data is used in connection with improvements. Improvements which can be quantified as economic savings are highly desirable but so are improved teaching conditions which can in turn lead to enhanced academic performance and improve the reputation of the school and result in higher numbers on roll which leads to greater funding. This progression takes POE form a *'stunted process'* (Cooper, 2001) to one which adds value across a range of applications.

The outcome of carrying out a BPCE for a primary school is very likely going to result in lower CO_2 emissions as a consequence of conducting the Energy Audit and looking in detail at the energy use for space heating, hot water, appliances and equipment etc. Areas where there are excessive energy use can be corrected often with low cost solutions. The consequence of conducting a detailed review of energy use is that a more efficient use of energy will result and inevitably lead to improved budget control which supports the findings by Wheeler & Malekzadeh (2015).

Theoretically a major beneficiary of the use of the BPCE system would be the asset management process in connection with the handling and management of building condition data. The BPCE process makes an important distinction between what elements of the building condition survey can be collected by the school staff as a housekeeping exercise, and what requires professional input to recognise and record. All of this data is currently gathered by the professional surveyor in the condition survey and a great deal of time is expended in doing so. In theory by dividing this the surveyor can be deployed just for those issues that need a professional input and thereby reducing the cost. The reduced survey can be held on a database which is accessible by the Head Teacher and the District Building Surveyor who together compile the SMIP and this can become a live document adjusted and changed as part of the review process. This completely removes the difficult asset management task of keeping the survey data up to date whilst it also calls for less centralised resources. This type of thinking could have wider implications on the future of building condition surveying for occupied buildings where clients wish to minimise their costs by spliting the content.

9.04 Implications for Practice

The idea that condition appraisals should be made in full cognisance of the performance of the building and that some issues regarding conventional building maintenance priorities should be place behind those relating to building performance issues seems to be a practical deduction from anyone closely involved with the management of the building. However despite being touched upon in a number of wholly inclusive methods for measuring building performance (Preiser & Nasar, 2008, Manning, 1965) this has not been the case and no major emphasis has been placed upon building condition apart from Total Building Performance (Hartkoft, loftnes & Mill, 1986) which saw the rather tenuous issue of Building Integrity as being worthy of evaluation. In many ways the development of the POE has, in fact, taken an opposite direction in looking to create a Building Performance Evaluation process model which focuses upon the relationship between design and the technical perfomance of buildings (Preiser, Mallory-Hill and Watson, 2012). These approaches have taken the stance that a more expansive view is required of the life of the building through such phases as Commissioning, occupancy, adaptive re-use, effectiveness review, programming and design review with a constant feedforward for the next building cycle. In terms of the ‘practice’ of managing building assets this is of little use and the more beneficial direction would have been to look deeper into the POE and discover its use in

the most basic aspects of practice through phases of planned maintenance, essential repair, improvement works, building condition data management etc.

The approach adopted by Preiser & Schram, 1997, Bordass, 2001, Gupta, 2005 and others seems to have arisen through the architectural design profession influencing the direction of POE. Designers want to receive feedback on what has worked and what has not worked in their schemes and this is essentially a recognisably good practice. However the POE has a great deal more to offer other professions such as building surveyors, asset managers, building services engineers and even the clients who occupy the building in managing the working conditions of their staff. So despite the RIBA reintroducing POE as part of their Plan of Work, other professions need to become involved in carrying out the process and controlling its future direction.

The 'walkthrough survey' that is referred to by in the Probe surveys (Bordass, 2001) is a very cursory examination of the accessible areas of the building and the random identification of situations that might be the source of building performance issues. Bordass did not carry out a detailed inspection of the building envelope, he did not investigate any possible moisture ingress or look for any building fabric or structure failure. In fact the internal inspection that he carried out had no rigorous pattern to it and seems likely to have overlooked any really serious problem with the building that would have completely overshadowed his evaluation. If the 'walkthrough survey' had been a full condition appraisal carried out by a competent building surveyor and a building services engineer then this would clearly be the start-point for a much more effective evaluation of the building. This is a very important implication for practice and for the collaborative work of building surveyors and building services engineers to create a fee income stream from carrying out BPCEs for their clients.

The implication for the practice of managing primary school buildings are the possible benefits form adopting a system that reviews energy and environmental issues that have been deemed to be important by head teachers. These issues aligned with building condition and occupier feedback come together to provide a tool for evaluating the primary school in a way that relies upon the triangulation of data to assist in the prioritising of planned maintenance work. The process of looking across different results offers the practitioner an endorsement of his decisions as to how best to prioritise the planned maintenance programme and thereby reduces the risk of making errors.

The findings from both the initial study and the BPCE interviews demonstrated that the Head Teachers had a strong interest in using a number of the measures to identify the performance of their school buildings, particularly those which affected the performance of their children in the classrooms and other teaching areas. In some discussions the prioritisation of improvement of classroom teaching conditions was considered to be important enough to be given a higher priority than other work identified as urgent in the condition survey.

The internal environment of the schools were measured by a datalogging process which gathered CO_2 concentration, Relative humidity and temperature every 90 seconds. The loggers were generally situated in classroom or teaching areas and there was no prior investigation or evaluation of the locations to establish if there was any existing problems. The graphs produced were built up over the course of a week to show how each of the three measures varied over time and occupier activity. The graphic presentation of how the CO_2 levels built up during teaching periods and then receded at times when the spaces were vacated gave an indication of how well ventilated the spaces were. The rate at which the CO_2 levels fell outside of the classroom occupation gave an indication of how air tight the spaces were with the doors and windows closed. This information was very useful in understanding the nature of the spaces under test and when looked at together across the school.

When this data was presented to head teachers and their teaching staff they could see how their behaviour in the spaces was affecting the air quality and in those cases where it was poor some provisions were discussed as to how to take some short term remedial action often by just opening windows for the times when the CO_2 was at its greatest concentrations. This often led to sudden and considerable heat losses during the winter months which was unpleasant and costly especially in schools where the heating was not very responsive. The use of the data to raise awareness of the teaching staff was very effective and the learning from this process is being replicated across the estate and in some severe cases the schools have elected to install mechanical ventilation with heat recovery units to improve ventilation and reduce the heat losses. The literature on the effect of CO_2 levels in the classroom has demonstrated that in high CO_2 concentrations i.e. over 2500ppm the levels of attention of the 5-11 year old occupants falls by up to 2.5% (Coley & Greaves, 2005) and this has been an influence for head teachers to try to improve the situation. The implication for CO_2 concentration, temperature and relative humidity monitoring in classrooms using a data logger is that they in themselves offer an excellent

diagnostic procedure for understanding the classroom envelope, ventilation effectiveness, moisture levels and the performance of the heating system. So the use of simple inexpensive and reasonably accurate data loggers may become as widely used as damp meters by practitioners in the future.

9.05 Contribution to Knowledge

This study of the processes involved in the asset management of primary school buildings has demonstrated the considerable complexity that exists and how this affects the use of resources in achieving well managed properties. The preceding chapters have outlined the current situation with regard to a large UK County Council and this offers an indication of the situation that may exist across the UK in many other similar organisations maintaining primary schools.
The analysis of the interviews has shown that the Head Teachers took a positive view of the method and thought that there was value to be obtained when the building condition was examined alongside the building performance issues. The maintenance priorities together with other performance issues such as those that have been measured using the POE techniques can be complimentary to each other and this was seen to be useful by the head teachers. In some cases they viewed the building performance based approach to understanding the requirements for their school buildings as something they would like to implement even if the available budget would not be sufficient to improve the situation.

The BPCE process as defined in the conceptual model (fig 9, page 95) was analysed using the five Es criteria from the Soft Systems Methodology and this produced a theory which suggested that there were good reasons for looking for performance priorities and that they should match or even exceed issues identified by the condition appraisal. the model was further refined by the results from the head teacher interviews and the systemic model was produced (fig 32, page 210). This model encapsulates the entire process as a system and the learning from developing this system is that the emergent property from the complete system offer something more as a complete set of activities. This emergent property achieves something more than the existing asset management approach as it enables the participant to view building maintenance and improvement projects in a different light. The additional sources of guiding information arise

from the three sections of the BPE that are new to the process i.e. the Energy Audit, the environmental appraisal and the occupier feedback. Some decisions will be made with supporting data from all three sections and this gives them a far greater robustness. This emergent property is probably the greatest contribution to knowledge from the production of the BPCE, that is an ability to triangulate the data to produce results of greatly increased robustness.

In some other instances the information gathered from parts of the evaluation endorsed the findings from other parts or offered no correlation at all and therefore reduced the priority of the particular issue either way the availability of the data strengthened the process as an evaluative technique. There were many instances in both the BPCEs where the condition information supported the findings of the energy audit, and the environmental audit and the occupiers feedback gave a significant verification of the performance of the building.

The closer control of energy both gas and electricity is something that has been a preoccupation for head teachers for some time. Rising energy costs have made it an important area to look for savings. The prediction for the future is bleak for any school that is using fossil fuels as their inevitable depletion is likely to bring much higher energy costs. Most schools require an annual DEC and this process will involve some analysis of the schools annual gas and electricity use. In many cases these figures are above what would be anticipated for average usage for the type of building although few schools take the action of finding out why or what is achieved in the use of their energy.

The methods used in the BPCE to further scrutinise the energy use have been in use for a considerable time and although they are an approximate process degree day analysis remains an interrogative and informative process. The head teachers interviewed understood the basis of the investigation and what it told them about their heating system in its responsiveness to external temperature change. In the case of the Victorian school the process revealed very poor performance which was corroborated by the internal temperatures and the occupier feedback making the decision to carry out further investigation an obvious high priority. The learning from this part of the BPCE is that a relatively small investigation of the effectiveness and efficiency of the heating system in this way can result in demonstrating a clear requirement to improve the system and make savings.

The detailed examination of the electrical energy use requires a survey of all light fittings and a check of the portable appliance listing and an examination of all hard wired installations. This is a time consuming exercise and will involve an inspection of every room in the school. Most schools within the authority have an annual portable appliance test and these results provide a list which can be checked and the power for each unit established or in some cases estimated. The estimate of the time of use of the appliance in any given school day is then estimated usually from a discussion with the staff who use it and this figure is then multiplied by the actual days in school for the year. Some appliances such as fridges and freezers are in use throughout the year and these are calculated for a continuous use. The BPCE report presents this appliance usage in a table which produces the annual use figure and the lighting is dealt with in a similar way with a lighting schedule produced which also identifies the lighting levels in each room. This extensive effort provides the school with some useful information about how their electrical energy is used and what their lighting is achieving. This is then compared with actual energy use and any differences can be further investigated. The data provides the basic information for devising a use strategy for energy and sustainability that the school can build upon. A number of head teachers showed an interest in involving the children in this process helping them to understand the importance of energy conservation whilst also seeing a benefit for the school.

The process of carrying out the BPCE and obtaining occupier feedback has resulted in a degree of scrutiny of the adopted format for gathering data which is the BUS survey developed by Bordass and Leeman (2005). Whilst this survey format was tailored slightly to fit the purpose of the BPCE it was found from the research that a more refined version could be used more beneficially and a revised version is contained in Appendix IV. One of the learning outcomes form conducting the occupier feedback surveys was that respondents can be put off making a thoughtful contribution by being asked questions that they think are irrelevant, as the reason for their inclusion has not been explained, or by the amount of questions being asked. It was also discovered that asking questions that have a high degree of difficulty disincentivises the respondents. The findings were that it was important to make the process as short and simple as possible and yet attaining the most relevant information from simple questions. This would result in the use of a different type of survey in future and one presented with some explanation for questions that have no obvious reason for their inclusion.

The positive findings from the occupier feedback was that the head teacher has an opportunity to manage the expectations and the morale of the teaching staff by placing their needs clearly with the priorities of the school as a whole. The performance monitoring and measurement of internal environmental conditions corroborated with the feedback from the teaching staff offers a much more powerful way of determining the actions required to improve the internal atmosphere of the school.

This research has highlighted the importance of providing a more focused, short term assessment process for monitoring the condition of the primary school buildings. The existing, conventional process of using building condition surveys to gather wide ranging information in great quantity has become partly redundant and unwieldy. The current practice guidance from the DfE suggests that there are twelve major elements for capturing data with almost 70 sub-elements (DfE, 2000). A process has evolved at the authority which started by simply identifying issues from the current condition survey that needed to be carried out and that could be afforded from the available budget. This evolved into a short schedule that also captured the cyclic statutory work and the head teachers planned improvement works and it became know as the school maintenance and Improvement Plan (SMIP). This research makes a contribution to the SMIP by introducing remedial works identified from the energy audit, the environmental appraisal and the occupier feedback and incorporating them in the survey. The outcome of doing this in the two BPCEs that were completed was to show how this work could resolve issues in more than one area and identify the true benefit of completing or prioritising the work.

An important phase in the BPCE process is the examination of the existing condition data or the carrying out of a condition survey to capture the current overall condition of the school and to identify the priorities for completing the work identified. The distinction was made between condition data that is of high priority, and possibly a legal requirement, and that which can be subjectively judged by the head teacher and the occupants. This provoked a consideration of what data should be gathered by professional surveyors and building services engineers and what should be left to the occupiers to make decisions on. This presented an opportunity to reduce the professional input on the subjective issues of redecoration, renewal of floor coverings etc and reduce the time spent making these assessments. This time saving could then be devoted

to the gathering of data for the BPCE or simply reduce costs and further improve the focus of the condition survey.

The completion of all statutory requirements and H&S issues clearly remains a priority and the control of this work needs to be robust but the opportunity to make long overdue improvements to the condition data management process for the authority is highly desirable. The current practice is for condition surveys to be carried out on every school within a ten year period and to gather large amounts of data. This data then serves as an indication of future funding requirements and informs the planned maintenance programme. However the management of the changes made over time by work being completed is an asset management administration task of some considerable difficulty gathering information about what work has been completed from a number of different sources. The BPCE process keeps the condition data up to date by an annual review process with the professional advisors and the head teacher. This is a very significant improvement on the current practice which would result in using better quality live data and a more efficient and cost saving process which can be updated with new condition data from any appropriate source when required.

The Systemic Model that has been developed demonstrates a process which suggests an improvement on the prevailing asset management practices in a number of aspects, although the BPCE does require more time and resources to complete. It is this cumulative effect of all of the small improvements which when put together represents the main contribution to knowledge for this research. It is the emergent property of the systemic model that combines all of the distinct improvements in the content and small enhancements of the process which ultimately achieves a better practice and a better user experience.

9.06 Future Research

The further development of this research should involve completing more BPCE reports on many differing types of primary schools in different areas and under different types of control. This would provide a significant body of data and offer an opportunity to analyse the overall benefits of carrying out improvements based upon the BPCE process compared with what the existing process would have delivered. If savings and improvements could be quantified then

this could be compared with the cost of completing the BPCE report and an attempt could be made to assess the perceived value of the process.

One possible avenue for future research could be to focus upon identifying the performance of older buildings and assessing their overall performance and gaining a greater understanding of the implications of occupying these buildings. Most of our built environment comprises older buildings and this seems likely to remain so in the future with todays valued building heritage remaining in use for many years to come. However the complete appraisal of these older properties will be necessary so as to ensure that their performance is fully understood and can be compared with alternative solutions.

Another area for further research would be to investigate how the BPCE could improve the building user experience and consider how much of the work identified through the occupier feedback is carried out and how this differs across different types of school buildings. Examining occupier feedback data and gaining a full understanding of the implications of resolving issues quickly or providing feedback on when something will be resolved or doing nothing should be fully understood as the impact of carrying out the survey is perceived as having a range of possible effects.

The environmental assessment section of the BPCE could be the subject of further research and the two aspects of this section i.e. the impact that the building has on the environment and the appraisal of the quality of the internal environment could be split into separate areas of focus. The energy usage is strongly linked to the CO_2 emissions and also to the internal environment conditions and these two could be regarded as being worthy of appraisal together. One of the important aspects of this research is ensuring that energy use is matched with internal conditions as it is important to find the balance between these two and to judge one school against another on the basis of their gas usage per m^2 is misleading if the operating temperatures of the schools differ widely. The important distinction is how the energy is used and what is achieved in its use.

The research has demonstrated that by providing a set of vital building performance data for the school in the context of building maintenance and improvement a new perspective can be taken on the asset management process. It is hoped that the knowledge developed through this research will offer an opportunity for a new way of thinking about building maintenance and asset management which is not divergent from building performance.

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Appendix I - Results from the initial study

Table 1A Maintenance and improvement questions - Coding exercise - Head Teachers

Questions 1-4 - All maintenance and improvement works and the use of the Building Condition Survey.				
Source	**Grouped codes**	**emerging patterns**	**Themes**	**Theory**
Head 3	BCS aid to funding			
Head 2	BCS for financial planning	Building condition survey used for		
Head 2	financial restrictions			
Head 5	BCS not used			
Head 6	BCS not user friendly			
Head 1	No BCS surveyor advice sought		Building condition survey used for financial	
Head 3	Aware of BCS			
Head 3	BCS used	BCS used in some form for prioritising building work	BCS used in some form for prioritising	Building condition survey is instrumental in prioritising building and H&S work and for
Head 6	BCS used			
Head 4	BCS used with DS input		Building condition is a major driver in prioritisation of building works	
Head 2	BCS useful			
Head 4	building condition			
Head 5	building condition		H&S	
Head 1	implementation of planned work			
Head 5	Central Govt funding initiatives to meet specific			
Head 3	current requirements	Building condition is a major driver in prioritisation of building works		
Head1	Reactive repairs			
Head 3	Planned works diligence prevents reactive			
Head 5	Planned works to prevent reactive escalations			

Head 1	safeguarding			
Head 5	nice working environment for staff and children			
Head 4	educational outcomes			
Head 6	educational outcomes	Educational outcomes		
Head 5	educational outcomes from the right			
Head 1	educationally driven			
Head 2	Educational outcomes			
Head 1	national curriculum driven			
Head 1	pastoral			
Head 1	Health and Safety			
Head 2	H&S			
Head 3	H&S	H&S		
Head 4	H&S			
Head 6	reactive H&S			
Head 4	legal compliance			
Head 1	competing with other schools			
Head 4	impressing parents	Impressing parents		
Haed 5	Impressing parents			
Head 1	selling to prospective parents			
Head 4	local resources			
Head 3	longevity		Educational outcomes	
Head 3	aesthetics	School appearance		
Head 4	cosmetic improvement			
Head 1	Modernising		Impressing parents	

Head 3	out of date buildings and higher performance	out of date buildings and higher teaching	School appearance	Well-being within the school environment is a major factor
Head 2	out of date teaching areas and higher standards of teaching required		Staff Moral	
Head 1	Staff make the best of a bad job			
Head 2	staff make the best of their situation	Staff Moral		
Head 4	staff moral			
Head 3	work place improvement			
Head 1	lack of skills or buildings role			
Head 2	professional advice	professional advice	professional advice	
Head 1	reactive escalations referred directly to DS			Head Teachers seek professional advice in pursuit of value
Head 4	value	Value	Value	
Head 6	value for money			

APPENDIX II - BPCE Interview analysis

Table 2A - BPCE Interview question 1 - Thematic analysis

Question 1 What are your first impressions of the report?				
Source	**Grouped codes**	**Emerging patterns**	**Themes**	**Theory**
School 4	well, it was really good I really liked it			
		really good, liked		
School 6	good		Report has good and useful content and is liked	
School 5	it was quite technical but well presented and long overdue			The Report has a good overall message and good content which is of interest to the head teachers
		technical well presented		
School 1	it is very large but parts of it were very well presented			
			Report has good content	
School 7	It was heavy going but it was worth it	content worth it		
			Report has interesting parts	
school 9	it was a bit heavy going but very interesting in places			
		difficult to read	Report is too dense and difficult to read	
School 10	It was very heavy			
		too long, too much detail		The report should be revised to take account of the reader and to reduce the content in places and to make the technical content more accessible to the reader.
School 3	It was very long and a bit too technical for me		Report is too long	
		content difficult to understand		
School 2	well, it was very technical			

Question 1 What are your first impressions of the report?				
			Report is over-technical to a significant degree for the head teachers	
		technical content renders the report valueless		
school 8	it was well over my head and I don't see any point in making comment on it really			

Table 3A - BPCE Interview question 2 - Thematic analysis

Question 2 Do you think that any form of building performance evaluation would be worthwhile and if so what would you say would be the most significant information ?				
Source	**Grouped codes**	**emerging patterns**	**Themes**	**Theory**
School 1	I don't know really….the CO_2 monitoring was very interesting			
School 3	I think there are areas in the school where we would like to know what sort of air quality we have there	CO_2 Monitoring has the ability to improve teaching conditions		
School 10	very worthwhile the air quality in the classrooms		CO_2 monitoring is seen as significant in improving teaching standards	
school 5	I suppose the internal air quality would be good to know.			
School 8	difficult to say really but the energy information looks useful			
		Energy audit asks questions which could result in desirable improvements and savings		
School 1	The report was a bit overwhelming but the air quality and the occupier feedback… and the energy analysis		Energy Audit is very significant as it can result in both improved internal conditions and savings not just a measure against other schools.	The whole of the BPCE is considered to be significant and the CO2 and Energy assessments are seen as the most useful sections. The environmental appraisal and the occupier feedback could be amended and reduced to provide just the critical
School 4	I think the energy information asks a lot of questions and identifies work to be done.			

Question 2 Do you think that any form of building performance evaluation would be worthwhile and if so what would you say would be the most significant information ?				
School 7	not sure…the energy analysis should replace the one in reception (DEC)	Energy Audit picks up from the DEC and takes the data to a more useful conclusion		information. greater explanation is required for the most technical areas of the reporting this may be fulfilled by further professional input in the interpretation of the data.
School 9	All good…I would keep it all			
School 4	yes … I think all of it really	the whole of the BPCE is significant		
School 10	I would be very happy to see the full report and see how it impacted on my SMIP		the whole of the BPCE should be retained and used	
School 3	I liked all of it really finding out about the lighting levels in the classrooms was good			
School 1	Well..hard to say… all of the environmental report would be useful	All of the environmental section of the BPCE is useful		
School 9	I like the energy assessment and the occupier feedback but some of the questions in it seem a bit unnecessary	occupier feedback form could be amended	Questions in occupier feedback need to be simplified	
School 7	I did not understand the custom or the control charts	Difficulty with the technical level of some of the techniques	some of the report is too technical	
School 8	I didn't understand most of it and we have been asking if someone could look at the boiler controls for ages			

Table 4A - BPCE Interview question 3 - Thematic analysis

Question 3 Would you see any of this information influencing decisions that you would be involved with for larger planned works or improvements?				
Source	Grouped codes	emerging patterns	Themes	Theory
School 1	well…yes I would expect a new classroom extension to provide excellent air quality			
School 6	Yes a lot really.. I would want to achieve good standards	setting standards from the findings of the BPCE		
School 7	Absolutely…I would be asking for really good environments in any new classrooms		Standards set by identifying remedial work for larger improvements and planned works through the BPCE	
School 10	I think I would want to see work carried out that would make things better and not ignore the issues in the report	The report is useful in identifying the existing situation and setting targets for new work to influence		
school 8	I suppose we would want to make sure about the ventilation in any new spaces			
School 4	It would be nice to see future investment providing better results		BPCE can be used for prioritising planned works and dictating the standards to be achieved	
school 9	I think some of this stuff would need to be considered before things like new blinds or carpets	Content of the BPCE report is seen as a high priority		The BPCE report contains information which could be used to set standards for schools, assist them with a strategy for maintenance and improvement works. The findings of the BPCE can influence planned works by highlighting the priority of building performance issues and occupier feedback issues. Professional input can be used for developing a strategy for the management of the school buildings and for the occupiers.
School 8	I don't know I would need to be advised by property	The report requires prof input to fulfil its potential		
School 6	we would love to know why our electricity use is so high, finding out why this is the case is more important that painting the hall and corridors this year		Further professional input could enable findings of the BPCE to be used to bid for additional funding	
School 3	I would like to have the classrooms checked and if they were poor then we would need to try and fund a solution	BPCE could be used to look for addition funding		

Question 3 Would you see any of this information influencing decisions that you would be involved with for larger planned works or improvements?				
School 6	we wouldn't consider installing our new windows now without knowing that we had adequate ventilation	Remedial works identified from the findings of the report are prioritised alongside the Planned and improvement works		
School 3	The SMIP in the report looks really interesting that would help to see all of the issues and corrective works identified and costed			
School 2	The feedback from the staff is something that we would want to focus on and showing a commitment to making their environment better	Occupier feedback is an influence upon prioritising improvement works	Occupier Feedback is an influence upon planned and improvement work	
School 2	The report points out multiple areas which can be improved upon, some are technical issues but many are operational issues which we can address so as to ensure that we have a well controlled comfortable environment…that is fit for all our needs but is achieved at minimal cost to the school and the environment.	The BPCE can provide the basis upon which to develop an overall strategy for managing the building as well as effecting improvements	BPCE can enable occupier feedback to be acted upon with planned works and improvements	

Table 5A - BPCE Interview question 4 - Thematic analysis

Question 4: Do you think any of this information should be gathered with the condition survey and used to inform the planned maintenance programme?				
Source	Grouped codes	emerging patterns	Themes	Theory
School 1	Well….I suppose so.. I would be guided by Property			
School 8	Would that mean only having the information every ten years or so?	Uncertainty professional advice needed but the right thing to do	uncertainty	
School 6	yes because some of the stuff in the condition survey is inappropriate			
School 7	Yes…do you mean as part of the survey?…I think some of this is just as important as condition items so yes.	BPCE content is as important as condition data	BPCE has important content which should be gathered and incorporated into the condition data for prioritisation	
School 3	I think all of the content of the report should be compared with the condition survey as it is more important in many ways	BPCE content is more important as condition data		
School 6	I think that would be an excellent idea		The report should be completed to investigate the condition and building performance	
School 9	I think it would be a good idea to routinely find out about the internal classroom conditions in both summer and winter.	Need to carry out the report on a regular basis or adopt the system of using the report		Further professional input is required to produce the BPCE wth the SMIP containing those works which have been costed and prioritised. Consideration to be given to the availability of additional funding should there be insufficient budgets to resolve the issues identified.
School 7	I think the full appraisal should be carried out and then monitored so that we can run the school at an efficient level..whenever we collect the data			
School 10	We cannot afford to carry out what work we know is required we would need extra funding to do more			
school 9	It would depend on the cost	Cost of completing work identified would be a problem	The cost of the works identified as high priority could prevent work being carried out	

Question 4: Do you think any of this information should be gathered with the condition survey and used to inform the planned maintenance programme?				
school 8	I don't know what we would do if all of this came back as needing lots of work doing…that would be a nightmare.			
school 6	We have dreadful overheating problems in the summer and this report might help in deciding how to resolve it.			
School 10	'why would you spend money on looking into something where there was no reason to believe there was a problem?'	problems should be addressed as they arise not by using a cyclical evaluation process	The report techniques should be used to solve problems as they arise	
School 2	I think the testing of the air quality should be tested once and then corrected			

APPENDIX III - Appendices 1-4 from the BPCE report on the modern school

Appendix 1 - schedule of planned maintenance requirements from the condition survey

School 2 - School Maintenance and Improvement Plan				
Planned Programme Maintenance and Capital Improvement Works	**Financial Year**	**Estimated Cost**	**Proposed Funding Source**	**Notes**
Statutory / Health & Safety Works				
5 Year Fixed Electrical Test (*BS 7671:ly2008*)	2019	500	Building Service Contracts	Electrical contractor - The retesting date is June 2019
3 Yearly Gas Safety Test (Gas Safety (*Installation and Use) Regulations 1998*)	2017	700	Building Service Contracts	
Legionella Risk Assessment Review	2016	200	Planned Prop	Desktop review and recommendations - from consultant
Legionella Risk Assessment (*The Control of Legionella Bacteria in Water Systems. Approved Code of Practice and Guidance (L8) 2000*)	2017	500	Planned Prop	Full risk assessment inspection to be carried out and works required prioritised - by consultant
Lead in water testing	2016	100	Planned Prop	Authority policy- one test required in 10 yr
CCTV service	2017	tbc		to be placed with specialist contractor
Maintenance service to entrance gates in connection with child protection issues	2017	tbc	Planned Prop	Installer - two visits per annum
Air conditioning servicing	2016	140	Building Services Contract	Two visits per annum by Mechanical engineers
Automatic doors	2016	300	Building Services Contract	Two visits per annum by specialist contractor
Legionella risk assessment		500	Building services Contract	
Water Temperature monitoring		inc	Building Services Contract	
Roller Shutters		150	Building Services Contract	specialist contractor - kitchen
Boiler servicing		414	Building Services Contract	
Lifts		120	Building Services contract	Two visits per annum by installer/manufacturer
Lightning Protection		350	Building Services Contract	Specialist contractor

School 2 - School Maintenance and Improvement Plan				
Planned Programme Maintenance and Capital Improvement Works	**Financial Year**	**Estimated Cost**	**Proposed Funding Source**	**Notes**
Fire Alarms		400	Building Services Contract	Two visits per annum
Intruder Alarm		300	Building Services contract	Two visits per annum
Essential Condition Related Works				
Preservative treatment to all external structural timber to Main building	2017/19	1750	Planned Prop	
Prepare and paint all timber outbuildings and sheds with preservative treatment	2017/18/19	2500	Planned prop	Phased work depending on age
Cleaning of all rain water gutters and valley gutters	2016/17/18	650	Planned prop	
Fungicidal wash treatment to aluminium fascias, soffits and edge trims to the main roof	2017	1200	Planned Prop	
Brick and stonework cleaning	2017/18	3500	Planned Prop	
	TOTAL			
Desirable or Improvement Works				
EYFS outdoor development work	tbc	tbc	Planned Prop	Further planned landscape improvement
Internal decoration Phase 1	2019	5000	Planned Prop	High use internal areas e.g. toilets, staircase and circulation areas
Internal Decoration Phase 2	2020	6500	Planned prop	Some classrooms, Nursery, staff room and reception area
Internal Decoration phase 3	2021	4500	Planned Prop	Remaining classrooms, office admin
	TOTAL			

Appendix 2 - Occupier questionnaires

	Occupant Questionnaire			total
	Building Performance and Condition Evaluation			
	This survey is being carried out as part of an academic exercise to assess the performance of the Building in use.			
	Please try to complete every section using the 1-7 scoring scale			
	If you have any queries please contact			
A	Background			
1	Role/position			
2	workplace location classroom/kitchen/office etc			
3	How long have you worked in this building?			
4	How many hours per day do you spend in the building?			
5	How many days do you spend in the building in a normal working week?			
B	The Building Overall			
1	All things considered how do you rate the building design overall			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
2	On the whole do the facilities provided meet your needs			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
3	How do you rate the image of the building			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
4	How do you rate your personal safety			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
5	Availability of meeting/break-out rooms			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
6	Suitability of storage arrangements			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			

C	Your work			
1	Please describe briefly the work you carry out in this building			
D	Your Work area			
1	How would you rate the furniture provided at your desk or work area			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
2	How would you rate the working space provided			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
E	Comfort in Winter			
1	Temperature in Winter			
	Uncomfortable / 1 /2 /3 /4 /5 /6 /7 /Comfortable			
	Too Hot / 1 /2 /3 /4 /5 /6 /7 /Too Cold			
	Stable / 1 /2 /3 /4 /5 /6 /7 /Varies during the day			
2	Air in Winter			
	Still / 1 /2 /3 /4 /5 /6 /7 /Draughty			
	Dry / 1 /2 /3 /4 /5 /6 /7 /Humid			
	Fresh/ 1 /2 /3 /4 /5 /6 /7 /Stuffy			
	Odourless / 1 /2 /3 /4 /5 /6 /7 /noticeable odours			
3	Conditions in Winter - Overall			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
4	General comment about heating			
F	Comfort in Summer			

1	Temperature in Summer			
	Uncomfortable / 1 /2 /3 /4 /5 /6 /7 /Comfortable			
	Too Hot / 1 /2 /3 /4 /5 /6 /7 /Too Cold			
	Stable / 1 /2 /3 /4 /5 /6 /7 /Varies during the day			
2	Air in Summer			
	Still / 1 /2 /3 /4 /5 /6 /7 /Draughty			
	Dry / 1 /2 /3 /4 /5 /6 /7 /Humid			
	Fresh/ 1 /2 /3 /4 /5 /6 /7 /Stuffy			
	Odourless / 1 /2 /3 /4 /5 /6 /7 /noticeable odours			
3	Conditions in Summer - Overall			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
4	general comment about ventilation/cooling			
G	Noise			
	How would you describe the effects of noise?			
1	Noise overall			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
2	Noise from people between rooms			
	Insignificant / 1 /2 /3 /4 /5 /6 /7 /Too much			
3	Noise from plant and equipment (eg HVAC and IT)			
	Insignificant / 1 /2 /3 /4 /5 /6 /7 /Too much			
4	Noise from outside			
	Insignificant / 1 /2 /3 /4 /5 /6 /7 /Too much			
	Any other comments about Noise			
H	Lighting			

	How would you describe the quality of lighting?			
1	Lighting overall			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
2	Natural daylighting			
	Too Little/ 1 /2 /3 /4 /5 /6 /7 /Too much			
3	Artificial Lighting			
	Too Little / 1 /2 /3 /4 /5 /6 /7 /Too much			
	Any other comments about lighting			
I	Comfort Overall			
	All things considered how do you rate the overall comfort of the building?			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
J	Health			
	Do you feel that the building affects your Health by making you feel less healthy or more healthy			
	Less healthy / 1 /2 /3 /4 /5 /6 /7 /More healthy			
K	Personal Control			
	How much control do you have over the following?	Tick if it is important to you		
	Heating			
	No Control / 1 /2 /3 /4 /5 /6 /7 /Full control			
	Cooling			
	No Control / 1 /2 /3 /4 /5 /6 /7 /Full control			
	Ventilation			
	No Control / 1 /2 /3 /4 /5 /6 /7 /Full control			
	Lighting			
	No Control / 1 /2 /3 /4 /5 /6 /7 /Full control			
	Noise			
	No Control / 1 /2 /3 /4 /5 /6 /7 /Full control			
L	Overall design			

	All things considered how would you rate the overall design of the school?			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
M	Any other comments that you would like to make?			
	Thank you very much for your help			

Appendix 3 - Occupier comments

BUS Question areas	Comment	group coding	emerging pattern	Theme	Theory
Comfort in Winter	Very good	Comfortable	Comfortable		
	Apart from minor teething issues with radiator set on full temp constantly - the issue was rectified quickly - if temp drops radiators are very efficient.	Comfortable and controllable	comfortable and controllable		
	Heating is good whenever we feel cold we turn hit up and when we feel hot we turn it down.	Comfortable and controllable	comfortable and controllable	good winter performance providing comfort and control	
	If the temperature drops the radiators are very efficient	controllable	controllable		
	The Heating is fine in the classrooms	comfortable	comfortable and controllable		
	Underfloor heating works well	comfortable	comfortable and controllable		
	A constant temperature is hard to achieve in all areas with doors opening and closing at different times	variable heating related to design of classroom	heating unable to respond to use		**Comfort in winter is good with some fairly minor modifications required**

	Heating is very responsive	controllable	controllable		
	some of the radiators don't work	problematic system design	problematic system design	heating unable to respond to use	
	Nice and comfortable throughout the year	comfortable	comfortable		
	Very good as it can be turned up or down according to the classes needs.	controllable	controllable	good winter performance providing comfort and control	
	Able to turn it up or down as required.	controllable	controllable		
	Always nice and warm	comfortable	comfortable		
	When classroom doors open at playtime it can cause a wind tunnel.	variable heating related to design of classroom	heating unable to respond to use	heating unable to respond to use	
	We use 2 out of 3 radiators as we feel that this is sufficient	variable heating	inadequate over designed system		
	Usually noticeably warmer in the afternoons	variable heating	variable heating		
Comfort in Summer	good	no problems	comfortable		
	Nice and cool in the summer as we have lots of windows to open.	good natural ventilation	comfort and control	Comfort and control	

	Facing the Sun - we can get warm in the summer and the windows don't open far enough so we have to open the outside door.	summer overheating	summer overheating poor air quality		
	windows don't open wide enough - air vents / roof windows not sufficient to cool down room.	summer overheating	summer overheating	Summer overheating is an issue	
	Can be very warm during the summer months	summer overheating	summer overheating		
	We wish we could open the windows a bit more	inadequate ventilation	Lack of control	poor air quality is an issue	
	Often open outside door	overheating lack of ventilation	summer overheating		
	Overall not too bad I use the windows. The Studio can get a bit warm and we have to open the doors	controllable	controllable overheating		
	In Summer when the heating is turned off the offices can be very cold	cold in Summer	problem with temperatures in the Admin offices	Problem with lack of temperature control in summer	**The school is suffering from general overheating and cooling in some conditions and requires further investigation and corrective measures**

	The toilets need to have windows for ventilation and the Nursery kitchen needs to have a window opening	inadequate ventilation	inadequate ventilation		
	It can get stuffy and humid but only on days when the summer weather is hot.	inadequate ventilation	summer overheating	summer overheating and air quality is an issue	
	We are in the shade when the sun is at its highest point	shading preventing overheating	shading preventing overheating		
	We often have to open the doors in the summer months and this can lead to noise disturbance and wind can be an issue.	summer overheating leading to other issues	summer overheating leading to other issues		
Noise	no issues with noise very good sound proofing	good sound insulation	good sound insulation		
	not a problem	good sound insulation	good sound insulation	Adequate sound insulation	
	Needs more soundproofing between rooms and the corridor on the upper level office, LRC etc	poor sound insulation	poor sound insulation		**Further investigation required to potential sound insulation problems in the classrooms and corridor area.**

	During the dinnertime the large numbers of children using the corridor disturb the children in the Nursery.	poor sound insulation from corridor to classrooms	poor sound insulation from corridor to classrooms	Problem with sound insulation in the school teaching area	
	In the upstairs rooms you can hear what people are talking about in the meeting rooms - no privacy.	poor sound insulation to Admin area	poor sound insulation to Admin area		**The School Admin Area Office suite requires further investigation and remedial work to resolve sound insulation problems affecting its use for certain purposes**
	Admin block has a suspended ceiling with no sound proofing and this causes confidentiality problems - school are rectifying this by adding soundproofing to key areas at a cost to school.	poor sound insulation to Admin area - funding of corrective action?	poor sound insulation to Admin area	Problem with Sound insulation within the Admin area	

	In the Admin area every conversation can be heard as it is an open void above the ceiling tiles. This has created a lot of problems with confidential meetings e.g. Child Protection and Finance.	poor sound insulation to Admin area affecting is use	poor sound insulation to Admin area		
Lighting	Lighting in classrooms are really good. Easy to use	good controllable lighting	good controllable lighting		
	The motion sensor lighting is very good.	good controllable lighting	good controllable lighting	General good lighting levels and controls	
	The Hall has fantastic natural light. Helps with all the windows	good natural lighting to Hall	good natural lighting		**Design of natural and artificial Lighting is generally good with some minor issues to be resolved**
	Some of the lights can trigger my migraines, the one in the Hall is the worst.	defective Flickering lighting	Defective lighting		
	The light movement sensor in the office is inconvenient at times if working at the computer the lights can go off and need to start waving arms about to get the lights to work.	poor lighting control	poor lighting control	Problems with specific lighting issues	

	The energy saving lighting to the corridors makes them very gloomy	poor lighting levels	poor lighting levels		
Overall	The Office needs to be more accessible to parents as time is wasted taking children upstairs / downstairs.	problematic layout design	problematic layout design		
	Reception class sinks are too high and children struggle to open the taps.	design defect	Defect requiring remedial action		
	more storage needed	Storage issue	Storage issue	Issues with the layout and provision	
	Put a few toilets down near the Hall not enough children toilets too many adult/disabled toilets.	problematic layout design	problematic layout design		
	overall very good - nice building indoors perhaps could have been more aesthetically pleasing from outside (looks like a medical centre not a school)	good design poor appearance	Good layout and interior design		

	It is a wonderful building we are so lucky to have such an amazing space	good design	good design	The school design is good	Overall The school design is highly thought of although there are some issues that will require further investigation and remedy
	This school has been designed beautifully with an inviting atmosphere. Fit for purpose well done to all those involved.	good design	good design		
	It is Fab - spacious, light and airy. Very very well appointed views and amazing outdoor space - Forrest schools, sports facilities - even staff parking. An incredible school to work in.	good design	good design		
	Some areas of flooring are staring to lift.	material defect	Further investigation required		
	Would prefer a larger parents room and also some additional private meeting rooms	Reorganisation issue	Reorganisation issue	Specific issues require further investigation and possible remedial action	

	Not enough workspace and serving area in the kitchen causing some operating difficulties.	problematic layout design	problematic layout design		
	There are some problems with drains in some rooms which can get quite smelly.	defective drains	defective drains		

Appendix 4 - Overall Occupier feedback summary

			SS							HT																						
		respondent	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	tot	ave	response	median	Mode
		Location	all	3	1	2	6	6	-	all	H	O	O	O	4	-	lrc	ey		7	5	5	8	K					
Building overall		Design	7	6	6	7	7	7	5	7	6	7	6	7	6	5	5	5	7	7	6	7	6	5	13	6.3	21	6	7
		needs met	7	6	6	7	7	7	7	7	5	7	6	5	7	7	5	7	7	6	7	6	7	3	13	6.5	21	7	7
		image	7	7	3	7	7	7	7	7	7	7	7	7	7	7	6	7	7	6	7	7	7	6	14	6.7	21	7	7
		safety	7	7	7	7	7	7	6	7	7	7	7	7	7	6	7	7	7	6	7	6	7	6	14	6.8	21	7	7
		break-out rooms	7	6	7	7	5	6	6	5	6	7	6	6	7	6	3	6	4	5	6	5	3	3	11	5.7	21	6	6
		storage	2	4	3	5	6	6	5	5	6	7	5	4	7	5	4	6	7	5	6	5	5	3	10	5.1	21	5	5
Your work area		furniture	7	7	7	7	7	7	7	7	6	7	7	6	7	7	5	6	7	5	5	6	6	6	13	6.5	21	7	7
		space	7	6	7	7	7	7	5	7	6	7	7	6	7	5	4	6	7	5	7	5	6	4	13	6.2	21	7	7
Comfort Winter	temp in winter	uncomfortable/ comfortable	7	6	5	6	6	7	5	7	6		7		7	5	7	7	7	6	7	7	7		12	6.4	19	7	7
		too hot/cold	3	4		5	4		5	5	4		4			5	4			3	6	5	4		61	4.4	14	4	4
		stable/ varies	4	5		5	4		5	1	4	7	5	7		5				6	6	5	5	5	74	4.9	15	5	5
	Air in winter	air still/ drafts	2	4		1	4	4	5	2	6	4	1	5	5	5	1	1		2	3	4	1		60	3.2	19	4	4
		dry/ humid	2	4		3	4		5	4	6	4	1	5	5	5	1	1		2	3	4	5		64	3.6	18	4	4
		fresh/ stuffy	5	4	6	4	4		5	4	5	4	2	5	5	5	1	1	2	3	3	4	4	5	76	3.8	20	4	4
		odourless/ odours	2	1		3	2		5	2	2	4	3	5	5	5	1	1		3	1	5	2		52	2.9	18	2.5	2
	Overall	overall comfort in winter	6	6	6	7	6	6	6	7	6	7	7	5	6	6	7	7	7	5	6	7	7	5	13	6.3	21	6	6
comfort Summer	temp in summer	uncomfortable/ comfortable	5	3	1	4	6	7	6	4	5	1	7	5	5	6	5	7	7	4	3	6	7		10	5.0	21	5	5
		too hot/ cold	5	4	1	3	4		5	2	5	7	4	6	5	5	3			3	3	5	2		72	4.0	18	4	5
		stable/ varies	4	4		4	5		5	3	5	4	2	6	6	5	1			6	5	5	6		76	4.5	17	5	5
	Air in summer	still/ draughty	2	4	6	2	4	4	5	1	2	4	1	6	3	5	2	1		3	3	4	1		63	3.2	20	3	4
		dry/ humid	2	4	6	1	4		5	3	2	4	2	6	5	5	2	1		6	3	4	5		70	3.7	19	4	2
		fresh/ stuffy	3	4	6	3	4		5	5	4	4	1	6	7	5	3	1	3	5	5	5	4		83	4.2	20	4	5
		odourless/ odours	2	1	5	2	2		5	2	2	4	1	6	7	5	1	1		3	1	4	2		56	2.9	19	2	2
	Overall	satisfactory/ unsatisfactory	6	5	2	6	6	7	6	3	4	2	7	5	5	6	6	7	6	5	3	6	6		10	5.2	21	6	6
Noise	overall	satisfactory/ unsatisfactory	6	6	6	7	7	7	4	7	7	1	7	6	7	4	4	7	6	4	7	6	7	4	12	5.9	21	6	7

	from people between rooms	Insignificant / Too much	3	2	1	5	1	4	1	1	4	7	7	7	1	1	6	1	6	4	1	1	3		67	3.2	21	3	1
	from plant and equipment	Insignificant / Too much	2	1	1	1	1	1	6	1	1	4	1	6	1	6	5	1	6	2	1	1	1	3	50	2.4	21	1	1
	from outside	Insignificant / Too much	2	2	1	1	3	4	6	1	1	1	1	5	1	6	6	1	6	2	1	3	2	3	56	2.7	21	2	1
Lighting	quality overall	satisfactory/ unsatisfactory	7	7	7	7	7	7	7	7	7	2	6	5	7	7	6	7	7	6	7	6	7	4	13	6.5	21	7	7
	Natural daylight	Too little/ Too much	4	6	6	6	4	4	6	5	4	4	5	6	7	6	5	4	4	6	4	5	4	1	10	5.0	21	5	4
	Artificial lighting	Too little/ Too much	4	5	4	5	4	4	5	5	4	4	4	5	4	5	5	4		6	4	5	4	4	90	4.5	20	4	4
Overall Comfort	overall comfort	satisfactory/ unsatisfactory	7	6	7	7	7	7	6	7	6	5	6	5	7	6	6	7	7	6	6	6	7	5	13	6.4	21	6	7
Health		less healthy/ more healthy	4	4	7	5	4	4	6	7	5	4	7	5	5	6	4	7	6	6	4	7	4	5	11	5.3	21	5	4
Personal Control	Heating	No control/ Full control	7	7	4	6	5	4	4	6	1	5	7	5	7	4	7	1	6	6	7	7	5	7	11	5.3	21	6	7
	Cooling	No control/ Full control	4	7	4	7	6	4	1	6	1	7	6	5	1	1	3	6	6	6	1	7	7	7	96	4.6	21	6	6
	Ventilation	No control/ Full control	4	7	4	7	4	4	6	6	6	1	7	5	1	6	7	7	6	6	7	7	7	4	11	5.5	21	6	7
	Lighting	No control/ Full control	4	5	7	7	6	7	7	6	6	3	7	5	7	7	1	7	6	6	7	7	7	4	12	6.0	21	7	7
	Noise	No control/ Full control	4	7	7		4	3	5	6	4	1	3	5		5	1	1	6	3	1	7	5	4	78	4.1	19	4	5
Overall Design	All things considered	satisfactory/ unsatisfactory	6	6	6	7	7	7	6	7	6	7	6	5	6	6	5	7	6	6	6	6	6	5	13	6.2	21	6	6

Appendix IV - Revised Occupier Questionnaire

	Occupant Questionnaire			total
	Building Performance and Condition Evaluation			
	Please try to complete every section using the 1-7 scoring scale			
	If you have any queries please contact			
A	Background			
1	Role/position			
2	workplace location classroom/kitchen/office etc			
C	Your work			
1	Please describe briefly the work you carry out in this building			
E	Comfort in Winter			
1	Temperature in Winter			
	Uncomfortable / 1 /2 /3 /4 /5 /6 /7 /Comfortable			
	Too Hot / 1 /2 /3 /4 /5 /6 /7 /Too Cold			
	Stable / 1 /2 /3 /4 /5 /6 /7 /Varies during the day			
2	Air in Winter			
	Still / 1 /2 /3 /4 /5 /6 /7 /Draughty			
	Dry / 1 /2 /3 /4 /5 /6 /7 /Humid			
	Fresh/ 1 /2 /3 /4 /5 /6 /7 /Stuffy			
3	Conditions in Winter - Overall			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			

	4 General comment about heating			
F	Comfort in Summer			
	1 Temperature in Summer			
	Uncomfortable / 1 /2 /3 /4 /5 /6 /7 /Comfortable			
	Too Hot / 1 /2 /3 /4 /5 /6 /7 /Too Cold			
	Stable / 1 /2 /3 /4 /5 /6 /7 /Varies during the day			
	2 Air in Summer			
	Still / 1 /2 /3 /4 /5 /6 /7 /Draughty			
	Dry / 1 /2 /3 /4 /5 /6 /7 /Humid			
	Fresh/ 1 /2 /3 /4 /5 /6 /7 /Stuffy			
	3 Conditions in Summer - Overall			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
	4 general comment about ventilation/cooling			
G	Noise			
	How would you describe the effects of noise?			
	1 Noise overall			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
	2 Noise from people between rooms			
	Insignificant / 1 /2 /3 /4 /5 /6 /7 /Too much			
	3 Noise from plant and equipment (eg HVAC and IT)			
	Insignificant / 1 /2 /3 /4 /5 /6 /7 /Too much			
	4 Noise from outside			
	Insignificant / 1 /2 /3 /4 /5 /6 /7 /Too much			
	Any other comments about Noise			

H	Lighting			
	How would you describe the quality of lighting?			
1	Lighting overall			
	Unsatisfactory / 1 /2 /3 /4 /5 /6 /7 /Satisfactory			
2	Natural daylighting			
	Too Little/ 1 /2 /3 /4 /5 /6 /7 /Too much			
3	Artificial Lighting			
	Too Little / 1 /2 /3 /4 /5 /6 /7 /Too much			
	Any other comments about lighting			
K	Personal Control			
	How much control do you have over the following?	Tick if it is important to you		
	Heating			
	No Control / 1 /2 /3 /4 /5 /6 /7 /Full control			
	Cooling			
	No Control / 1 /2 /3 /4 /5 /6 /7 /Full control			
	Ventilation			
	No Control / 1 /2 /3 /4 /5 /6 /7 /Full control			
	Lighting			
	No Control / 1 /2 /3 /4 /5 /6 /7 /Full control			
	Noise			
	No Control / 1 /2 /3 /4 /5 /6 /7 /Full control			
M	Any other comments that you would like to make?			

	Thank you very much for your help			